sea turtles

of the Atlantic and Gulf Coasts of the United States

Carol Ruckdeschel
and C. Robert Shoop

Foreword by James R. Spotila

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Carol Ruckdeschel and
C. Robert Shoop with
Meg Hoyle, Photo Editor

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Contents

Foreword by James R. Spotila vii

Preface ix

Acknowledgments xi

About Sea Turtles 1

Evolutionary History 4
Juveniles 5
Adults 8
Mating Behavior 11
Nesting 12
Eggs and Hatching 16
Diet and Feeding 18
Disease and Parasites 21
Predators 23
Conservation 26

Species Accounts 33

Leatherback 35
Loggerhead 53
Kemp's Ridley 69
Olive Ridley 79
Green Turtle 85
Hawksbill 97

Epilogue 107

Appendix: Keys to Sea Turtles of the U.S. Atlantic and Gulf Coasts 109

Glossary 125

Additional Selected Reading 131

Index 133

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Foreword

Sea turtles are among the most magnificent marine creatures, with a charisma that makes them almost mythical. Although relatively few people have ever seen a sea turtle in its natural habitat, most of us know them from films and speak of them with awe. In addition to their aesthetic value, sea turtles can tell us much about the condition of the sea. We cannot see the sharks, tuna, swordfish, whales, and many other sea animals that are being devastated by industrial fishing and pollution, but sea turtles must come ashore to nest, and this allows us to count them and assess the health of individuals and populations. What is happening to sea turtles today is also happening to the rest of our sea creatures, or soon will be.

Although the United States leads the world in sea turtle protection, the effects of our burgeoning population are taking a terrible toll on sea turtles. As more and more people move to the coast to enjoy the sea and sand, we are loving the beach — and by extension sea turtles — to death. Shorefront development and the lights that go with it, highways, and beach renourishment and armoring are destroying the quality of nesting areas that have been used by sea turtles for millennia. Loggerheads are in great danger in the Carolinas and Georgia, and every species is threatened by human activities all along the U.S. coast. Unless we change our behavior, we will drive sea turtles to extinction in U.S. waters.

Fishing activities have an impact as well. Gill nets, long lines, crab and lobster pots, and trawl nets are taking a heavy toll on sea turtles as well as other sea creatures. Thousands of sea turtles each year are caught in these devices and die. Moreover, hundreds of turtles are injured or killed by collisions with boats both large and small. Sea turtles wash ashore dead on the Atlantic coast from north of New Jersey south to Florida and west along the Gulf coast to Texas.

On the bright side, conservation efforts have been successful in saving the Kemp's ridley turtle from imminent extinction. Leatherbacks are on the rise along the Atlantic coast of Florida, and green turtles appear in large numbers there as well. The largest population of loggerheads in the world nests in Florida. And as it has been in the past, education continues to be an important aspect of sea turtle conservation.

This book is an excellent resource for all who are interested in sea turtles, from high school students to homeowners, beach visitors, graduate students, and marine biologists. The knowledge and passion Carol Ruckdeschel and the late Robert Shoop have brought to their subject captures the reader's imagination. In clear language they present the evolution and biology of sea turtles, including interesting details on their parasites and diseases. The section on conservation provides essential information, and the guidelines for observing nesting are useful for all beach visitors. The species accounts are fascinating, and the key to the species is helpful to all readers. The illustrations make the book attractive as well as informative.

Sea turtles need all the friends they can find, and they have had no better friends than Bob and Carol. It is the turtles' loss and our own that Bob passed away in 2003. He was both a truly honorable human being and a wonderful colleague to sea turtle biologists. We are fortunate that Carol has expanded on their earlier work together. Her expert knowledge, gained from 30 years of experience on the beaches of Georgia, pervades this book. *Sea Turtles of the Atlantic and Gulf Coasts of the United States* will, I hope, be another step on the long road back to abundance for sea turtles along the U.S. coast.

James R. Spotila
Betz Chair Professor of Environmental Science
Drexel University

Preface

Sea turtles are an important part of our native fauna. Although rarely seen, they are seriously affected by human activities. Sea turtles must lay their eggs on beaches, and that need often puts them in conflict with human beach users. And because they feed in the same areas from which we gather our own seafood, many fall victim to commercial fishing gear. The purpose of this book is to raise awareness of sea turtles, their needs and their contributions, so that we may appreciate the species that live in the waters around us. The book is aimed at a general audience with little knowledge of sea turtles. The first part discusses general sea turtle biology. The individual species accounts that follow describe specific distributions, attributes, behaviors, and past and present threats to the survival of each species. The keys at the end of the book will help to identify species in various states of preservation, such as may be encountered on a beach. The glossary defines specialized terms.

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Numerous agencies have contributed to the support of our studies, including the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Georgia Department of Natural Resources, the Turner Foundation, and the Smithsonian Institution. General support from the Cumberland Island Museum and the University of Rhode Island is also gratefully acknowledged. The National Park Service on Cumberland Island provided radios for communication and notified us of stranded animals.

G. R. Zug initiated this writing project and contributed to an earlier version. The comments and suggestions of three anonymous reviewers were of enormous help and greatly improved the organization and content of this work, which was further enhanced by the expert counsel of Ann Mahoney and Melinda Conner. The generous contributions of numerous photographers are gratefully acknowledged.

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Sea Turtles of the Atlantic and Gulf Coasts of the United States

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About Sea Turtles

All turtles are reptiles, and all have a shell consisting of two parts: the top is called the carapace, and the bottom, the plastron. Instead of teeth, turtles have a horny covering on the beak, the rhamphotheca. The front limbs of sea turtles are modified to serve as paddles and are longer and flatter than those of freshwater turtles; the hind limbs are used as rudders. Unlike most freshwater turtles and tortoises, sea turtles cannot withdraw the head and limbs inside the shell. Otherwise, the general body plan is similar to that of other turtles. Although sea turtles spend almost all of their lives in water, they must breathe air and lay their eggs on land.

Sea turtles grow much larger than freshwater turtles. Their large size protects adults from most marine predators except for killer whales and large tiger sharks. But size is only a vague indication of age. Unlike mammals, which mature and stop growing at a certain age, reptiles grow and mature in relation to the amount and quality of food available. There is a minimum size for sexual maturity for each species, but the age at which that size is reached may vary dramatically from one individual to the next. Individual turtles have been recorded nesting for at least 20 years, and their life span may be similar to ours.

Five species of sea turtles may be found along the U.S. Atlantic and Gulf coasts: leatherbacks, loggerheads, Kemp's ridleys, green turtles, and hawksbills. Leatherbacks are present throughout the year, although some migrate as far north as Labrador and Baffin Island during the warm months. Loggerheads are found in temperate waters nearly worldwide, while Kemp's ridleys are restricted to the Gulf of Mexico and Atlantic Ocean. Loggerheads and Kemp's ridleys range northward to New England and the maritime provinces of Canada during warmer months. Green turtles and hawksbills inhabit tropical seas worldwide. Both species are occasionally found in New England waters, but they are much less common there than the other species. Hawksbills are generally restricted to tropical and subtropical waters, but green turtles range into temperate waters as well. A sixth species, the olive ridley, is not a regular inhabitant of the U.S. Gulf and Atlantic coasts,

A leatherback (dermochelid), above, and a Kemp's ridley (cheloniid), facing page. Courtesy of the National Park Service, Canaveral National Seashore, and Peter C. H. Pritchard, Chelonian Research Institute.

but there are three recent (2003) records from Florida. All three of these animals had physical problems and may have been transported there by ocean currents. One was entangled in fishing gear, one was found dead and emaciated, and the third washed up covered with tar. Olive ridleys inhabit tropical oceans worldwide, but as they are not usually found in the area covered by this book, we will not address them in detail here.

The Kemp's ridley is the most endangered of the sea turtles and has the most limited nesting range—primarily Tamaulipas, Mexico. The other species nest worldwide, including on the beaches of the southeastern United States.

All of our sea turtle species are listed as Endangered by the U.S. government and the International Union for the Conservation of Nature (IUCN). Degradation of marine and beach habitats, overexploitation, and high rates of incidental death associated with commercial fishing make their long-term survival uncertain at best. In the United States the authority for their listing stems from the Endangered Species Act; internationally it stems from the Species Survival Commission of the IUCN.

Few people are aware of sea turtles in the waters off the northeastern United States because the turtles spend most of their time below the surface

taking advantage of the abundant food there. From North Carolina southward, sea turtles are better known to the general public because they may be seen on summer nights when females come out of the water to lay eggs.

Conducting research on a migratory species that spends much of its life in the open ocean is difficult, and there is still much to learn regarding the biology of sea turtles. When females come ashore to nest, biologists can easily observe their activities, so more is known of females and the nesting process than of males and of activities away from the nesting beach. In recent years, satellite telemetry has been helpful in determining migration routes and general patterns of activity.

We have tried to provide comparable information for each species, but that was not always possible. Because the loggerhead is the most common sea turtle within the geographic scope of this book, slightly more detailed information is presented for it than for the other species.

Evolutionary History

Sea turtles are of an ancient lineage. They existed before the time of the dinosaurs, and there were once many more species than there are today. Sea turtles have survived the breaking up and drifting of continents on the earth's surface, the creation of new oceans, ice ages, catastrophic volcanic activity, and an asteroid impact severe enough to contribute to the demise of the dinosaurs. They were thriving for many millions of years before the first mammals appeared, and their large numbers may once have had a significant impact on the ecology of the planet's seas. Adult green turtles, along with the relatively uncommon dugongs and manatees, are the only large vertebrate herbivores in the oceans. The effects of green turtle grazing may have modified the biology of sea grasses and algae and the organisms living in those habitats just as bison once influenced the ecology of North America's prairies. When we see a female sea turtle hauling her enormous body across the beach to dig a nest cavity and deposit eggs, we are witnessing the result of many millions of years of evolution.

The two families of sea turtles that exist today arose at different times, probably from different ancestors. The Dermochelyidae (leatherbacks—with a more or less flexible carapace, represented today by only one species) are known from fossils 83 million years old. The ancestors of the Cheloniidae (hard-shelled sea turtles, including all species other than leatherbacks) are

Archelon—The Largest Sea Turtle Known

The largest fossil sea turtle found to date is *Archelon ischyros,* which swam the Cretaceous seas between 65 and 145 million years ago. It was a giant turtle between 3 and 4 meters long (12 feet). No member of its family survives today.

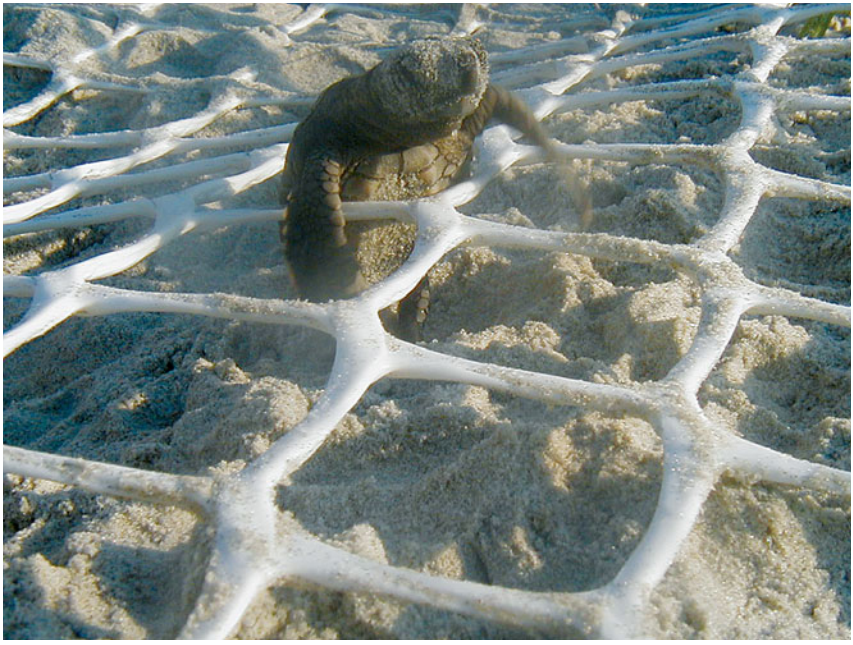
known from fossils in the early Cretaceous period, about 110 million years ago, but the surviving species appeared millions of years later.

Juveniles

A frenzy of activity lasting roughly 24 hours characterizes hatchlings that have just emerged from their nests in the sand. During that time they make the perilous trip across the beach, enter the sea, and make their way toward deep water. The males will never again leave the sea. During the time between their first entry into the sea as hatchlings and their return to the area as adults, sea turtles face an array of challenges. They must navigate ocean currents, avoid predators, find sufficient food, and survive their encounters with humans. Although we know quite a lot about nesting female sea turtles and hatchlings, we know very little about the biology of juveniles after they enter the sea. Most of what we know comes from incidental captures, stranded individuals, anecdotal information from fishermen, and recent turtle studies.

Very small post-hatchling juveniles do not compete with adults for food or habitat. They do not eat the same foods or occupy the same areas. Although they can swim in a straight line using a variety of cues, small turtles may live and travel within the ocean currents. Small loggerheads and ridleys appear in the eastern Atlantic waters around the Azores and European shores within months of hatching, apparently moving in the Great North Atlantic Gyre (a gyre is a circular movement of water). Some of these small turtles also appear in New England waters, possibly aided by the small Gulf Stream gyres that spin off the main current, but most presumably reside in the Sargasso Sea, an area defined by encircling strong currents and characterized by the floating algae for which it is named.

Except for areas where nutrient-rich colder waters well up from the depths and convergence zones where currents come together, open-ocean waters



TOP
Loggerhead hatchlings.
Courtesy of the Georgia Department of Natural Resources.

BOTTOM
A loggerhead hatchling emerges through predator screening.
Courtesy of the Georgia Department of Natural Resources.

A juvenile loggerhead. Courtesy of the Georgia Department of Natural Resources.

are not very productive and have few large predators. Very small turtles are probably safer in such areas, but food is not plentiful there and is often distributed in patches. As a result, growth may be quite variable and sporadic.

Small juvenile cheloniids, including green turtles, which as adults are herbivorous (i.e., they eat only plants), consume animal foods, including many types of invertebrates. In captivity they feed voraciously on chopped fish, scallops, and even commercial fish food pellets, so it is likely that young sea turtles are opportunists that feed on any animal matter available to them. Small leatherbacks no doubt eat soft-bodied marine organisms.

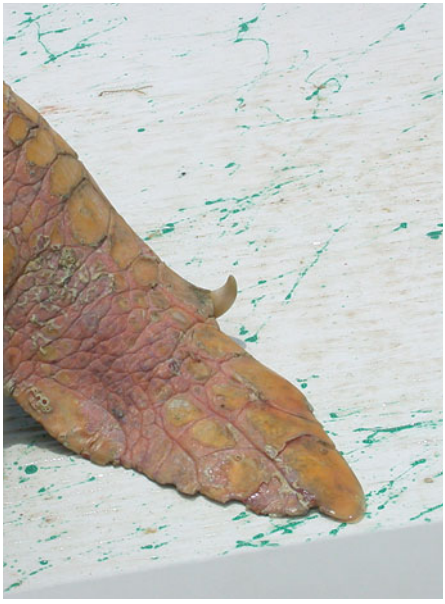
Given abundant food, small sea turtles grow rapidly and eventually reach a size that protects them from many marine predators. At that time they leave the open ocean and appear in continental shelf waters or reefs, including shallow estuaries and tidal creeks, where they can forage (i.e., look for food) on the abundant bottom organisms and invertebrates found in the water column. Although information for some species is lacking, we know that the juvenile stage for cheloniids usually lasts more than a decade, the early part of which is spent in open-ocean habitat and the latter in shallow inshore waters. The size at which cheloniid turtles move into shallow or reef waters differs according to the species and the habitat, and the turtles found in any given foraging area may include a variety of species from a range of birth sites. Juvenile leatherbacks remain in the open sea and feed primarily in the water column.

A tidal creek where juvenile turtles feed. Courtesy of Jeff Lovich.

In captivity small cheloniids sleep at night and rest with their flippers folded up onto their backs, a posture that may prevent predators from nipping off a dangling flipper. If they are not floating at the surface, they occasionally rise to the surface to breathe. When a small green turtle resting at the surface in that manner is tapped on the shell, it quickly dives and scurries around on the bottom of the tank. This sort of behavior could be a response to an avian predator such as a gull or tern.

Adults

As sea turtles approach sexual maturity, physiological and morphological changes begin to take place. In females, the many ovarian follicles that will form eggs begin to enlarge, and the overall body growth begins to slow. In males, the internal testes enlarge, the claws become strongly curved to help the male hold onto the carapace of the female during mating, and the tail begins to lengthen. The lengthening of the tail positions the penis out beyond the end of the male's shell, facilitating copulation. The vertebrae that



A loggerhead claw (ventral view, left front flipper). Courtesy of the Georgia Department of Natural Resources.

form the male's tail become enlarged as well so that all are larger than the corresponding vertebrae of adult females (tail enlargement in male leatherbacks is less striking). The female's tail does not become enlarged, so as adults the two sexes are easily distinguished by this feature.

Shell growth of adults slows dramatically, so much so that adult females marked with permanent tags while on the nesting beach show little change in size across the years from nesting cycle to nesting cycle. Very old sea turtles, especially cheloniids, have heavily ossified skulls. The sutures between the bones that make up the skull are obliterated, and the shell becomes strong and heavy, unlike the loosely constructed skulls and shells of juveniles; hence, growth after sexual maturity may consist more of increasing ossification than an increase in length. In general, carapace length is the primary measurement for size.

Most adult turtles regularly migrate between wintering habitats, warmer-month foraging grounds, and, in the case of breeding males and females, nesting areas. These locations are sometimes hundreds of miles apart. Their amazing navigation techniques are presently being studied and are believed to be associated with the earth's magnetic fields. The rates of travel can be relatively rapid, but if food is abundant along the way, the turtles may seem to

A male loggerhead (above) and a female green (below).
Courtesy of Michael White and Meghan Smith.

How Do Sea Turtles Navigate?

Sea turtles may cover great distances in their seasonal migrations between breeding and feeding areas. The cues they use to find their way from one area to another are currently a hot topic of research. The various species may exhibit variation in the mechanisms they use to navigate, and a species may use different methods in different situations. Among the possible guides are the intensity and inclination of the earth's magnetic field, the direction of waves and currents, chemicals in the water, water temperature, and, of course, visual features of the bottom.

ramble slowly along. Nesting females may delay or entirely forsake their migrations to foraging areas and migrate instead to nesting areas. Large leatherback females that had recently nested, undoubtedly on tropical or Florida beaches, have been documented in New England, where they had migrated to feed. Kemp's ridley adults do not normally leave the Gulf of Mexico, although some juveniles migrate to foraging areas along the U.S. Atlantic coast. Most species seem to have particular foraging and nesting areas to which they return, although foraging may be opportunistic for leatherbacks.

Migrating sea turtles may bring parasites or diseases along with them. This aspect of sea turtle biology has received very little attention but will probably be a topic of interest in the coming years. Like long-lived crocodilians (crocodiles, alligators, caiman, etc.) that may serve as reservoir hosts of the West Nile virus, sea turtles may prove to be important hosts for organisms or viruses.

Mating Behavior

Copulation takes place in the water prior to nesting. During copulation the male mounts the female, his belly to her back. He holds onto her shell with the claws on all his flippers as he twists his long tail down and around her tail so that the vent (opening) of his cloaca meets the vent of hers. He then extends his penis directly into her cloaca.

Females can mate with more than one male, so the clutches of eggs a female lays may have several fathers. The sperm the female receives during these multiple matings is stored for the duration of the nesting season. Females usually mate and lay eggs every 2–4 years.

Nesting

Sea turtles lay eggs in sand dunes above the tide line during the warmer months of the year. To be successful, a nest must be placed above the groundwater level and preferably above the reach of a spring or storm tide that might flood it. All species except for Kemp's ridleys usually nest at night and follow a similar pattern of behavior, with minor species-specific quirks. When a female emerges from the surf, she is wary and easily frightened. Movements, lights, or very loud noises may cause her to move back into the surf, perhaps to reappear later at another location on that beach or a nearby beach. If she detects no danger, she begins a slow and ponderous crawl up toward the dunes, apparently lured to the darkest horizon. Her limbs, so well adapted for swimming, are poorly suited for terrestrial travel, and her course is punctuated by resting spells during which she continually assesses potential hazards. The gait varies according to species; some use the opposing limbs alternately (e.g., left front leg with right hind leg), and some use them simultaneously (e.g., both front legs, then both back legs). As she reaches the high beach, the female may press her snout into the sand, apparently searching for cues that will help her determine a suitable nest site.

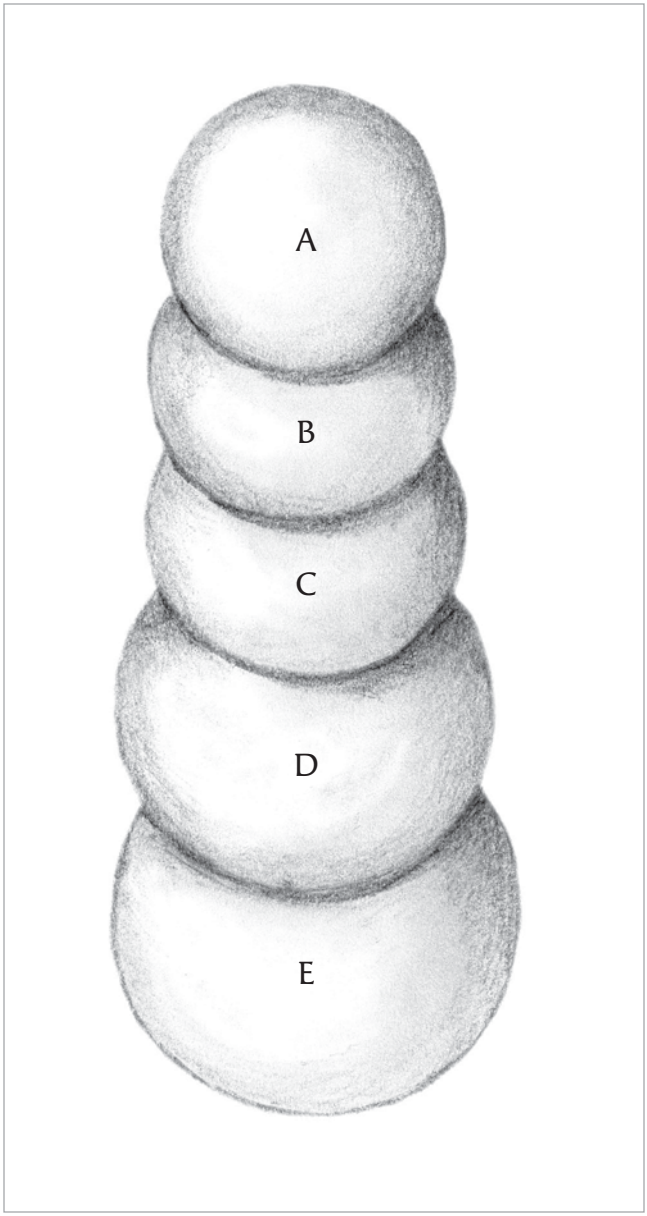
Females of some species dig an elaborate body pit, sweeping away loose surface sand and slightly burying themselves, before beginning to dig the

A loggerhead covering a nest. Courtesy of the Georgia Department of Natural Resources.

A leatherback laying eggs. Courtesy of Alejandro Fallabrino.

nest chamber in firm, damp sand; others dig with little site preparation. All species require well-packed, usually damp, sand below the loose, dry surface sand to hold the contour of the nest. The egg chamber is excavated with alternate scooping movements of the hind feet. The clenched foot is carefully inserted into the hole, and a "handful" of sand is scraped from below, lifted out, and pushed to the side. At that moment, the opposite rear flipper is kicked up in a forward motion to rid it of any sand before being carefully inserted into the cavity. Alternate use of the rear flippers provides nest symmetry and effectively disperses the unwanted sand. The hole is maintained at a minimal diameter until it is deep enough for the leg to be fully extended. Sand is then scraped away from the bottom walls, enlarging a lower cavity so that the entire structure becomes flask shaped. Most turtles use this method of nest construction, although freshwater turtles and tortoises do not kick sand or soil forward.

When the excavation is completed, the female positions her tail over the hole and begins to expel eggs one at a time, occasionally two or three nearly simultaneously, from her cloaca. The number and size of eggs are different for each species (see Fig. 1), with the largest species, leatherbacks, laying the fewest (the average clutch is less than 100) and largest eggs. Most species lay between 100 and 150 eggs during each nesting. All eggs are round, white, and have leathery shells. Sometimes odd-shaped eggs occur, and leather-



A hawksbill
B Kemp's ridley
C loggerhead
D green
E leatherback

Figure 1. Actual average sizes of different species' eggs.

Nest Site Fidelity

Biologists once assumed that females returned as adults to nest on or near the beach where they hatched. Tagging studies have shown that most nesting females return for many years to nesting sites close to where they nested previously. The fact that almost all Kemp's ridleys nest on a single stretch of beach in Tamaulipas, Mexico, demonstrates that such precise navigation is possible for sea turtles. Except for the ridleys, however, the question of whether females nest on the beaches where they were born remains unanswered. Attempts to mark hatchlings have been unsuccessful. Recent molecular genetics techniques have shed some light on the question. Studies have shown that subpopulations of sea turtles exist, which supports the idea of adult females returning to their natal beach to nest.

Such conservative behavior works well if the beaches remain suitable for nesting, but if the beach is destroyed or altered in a way that makes it unsuitable, conservative turtles are at a disadvantage compared with turtles that do not show strict nesting site fidelity. On the other hand, turtles without nesting site fidelity may be less likely to nest in suitable sites. Certainly it pays for the population to maintain at least some individuals that exploit new areas instead of returning to familiar sites; but overall, those returning to natal beaches must have some advantage (more successful offspring) or nesting site fidelity would not have persisted.

backs and hawksbills regularly include many undersized, yolkless "eggs" (shelled albumin) in their clutches.

When the female has deposited all her eggs, she stretches her hind flippers to pull the sand piled to the side during the excavation into and over the nest cavity. Ideally, the eggs fill the lower chamber only and do not pile up in the neck of the chamber. Too many eggs for the size of the nest may jeopardize the entire clutch. The closer to the surface the eggs are, the more likely they will be detected by predators that hunt by smell, such as raccoons, especially if one or two eggs are broken during the covering process. When the cavity is covered with sand, the turtle begins camouflaging the area to make the nest less obvious to predators. Using wide sweeping motions with the front flippers, she gradually crawls forward off the nest site, packing the sand beneath her while continuing to disturb the adjacent area in wide arcs. After a few feet of such camouflaging maneuvers, she makes her way back to the sea.

A leatherback hatchling emerges from an egg. Courtesy of Alejandro Fallabrino.

Eggs and Hatching

The average incubation time is similar for all sea turtle species (50–65 days) but varies with temperature and thus to some degree with geographic latitude. The development of the embryo is temperature dependent: cool temperatures slow development and increase the incubation period; warm temperatures speed development and shorten it. Temperature extremes are detrimental and even lethal to embryos. Temperatures between 26° and 32°C (79°–89.6°F) are safe, but temperatures above that range become increasingly lethal even with shorter periods of exposure.

The sex of each hatchling is determined by the temperature in the nest. In general, higher incubation temperatures produce females, and lower temperatures produce males. Many factors can affect nest temperature. Rainy or overcast weather keeps the sand relatively cool and can produce all-male

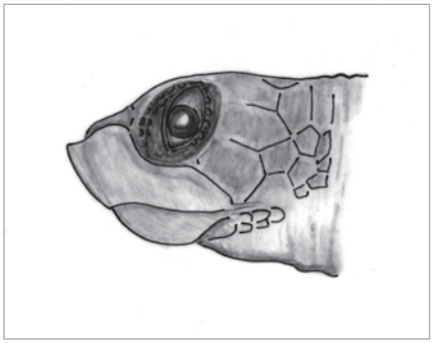


Figure 2. The sharp-edged caruncle on the tip of the snout, used by the hatchling to cut the eggshell.

clutches. Conversely, hot, sunny weather may produce all females. Even intermittent shading by vegetation may affect the proportion of sexes in a clutch. Temperature is rarely uniform throughout a nest, however, so both sexes may develop. Heat produced by the metabolism of the embryos raises the nest temperature, and the center of the nest loses this heat more slowly than do the edges. Eggs in the center will thus incubate at a slightly warmer temperature than eggs along the edge.

Water and humidity are also important for normal development of the embryos. Eggs in dry nests produce smaller and lighter hatchlings, and if conditions are too dry, embryos are killed by dehydration. On the contrary, too much water in the surrounding sand prohibits necessary gas exchange and can cause suffocation.

When embryonic development is completed, hatching begins. Each full-term embryo curled in its round shell has a sharp-edged egg tooth called a caruncle on the tip of its snout (Fig. 2). The hatchling turtle uses this device, which is lost soon after hatching, to slice through the leathery eggshell and then escapes into the nest chamber. As the flexible eggshells get pushed to the bottom and packed down, the hatchlings have more room to move within the nest. Sometimes hatching occurs nearly simultaneously throughout an entire clutch as the movements of one hatchling stimulate the others, but usually it takes place over 2–3 days. It takes a day or two for the hatchling's carapace and plastron to uncurl and the yolk sac to be completely absorbed by the body and used for energy. The hatchlings will emerge from the nest about 5 days after actually leaving the eggs. The first emergence from the nest chamber usually involves numerous hatchlings. When one moves, the activity triggers adjacent individuals, and so on. The uppermost turtles shave sand from the roof of the sealed cavity, and it filters

Plants that Eat Turtle Eggs?

Occasionally a clutch is laid close to beach vegetation such as sea oats or railroad vine. Nutrients that leach out of the developing eggs or fluids released at the time of hatching or when eggs are broken can cause the fine roots of nearby plants to grow and encircle some of the eggs, imprisoning late-developing embryos inside their shells. One author described that event as plants preying on turtle eggs, but it is a rare event.

down through the struggling mass of hatchlings. In this way they slowly ascend in a group. If the sand is cool when they near the surface, they may emerge en masse and hurry down the beach to the water, attracted to the lightest horizon. If the surface sand is hot when they approach, as it would be during most daylight hours, movement ceases and the inactivity spreads downward as the group waits for a proper temperature cue. This reaction to temperature at the time of emergence prevents the hatchlings from being exposed to possible overheating and dehydration. It also keeps them safe from the many daytime predators, especially birds, on the lookout for the young turtles.

It is rare for all individuals in a clutch to develop on the same schedule, probably because the temperature varies within the nest. There are usually two to four separate group emergences over a period of several days from any given nest. Those who develop and emerge first have an advantage over the later ones. They have the element of surprise on their side and may race to the sea unchallenged by predators. If foraging ants or a hunting raccoon or hog follows their trail back to the nest, the hatchlings remaining inside may be doomed, especially if the nest cavity remains open. If the escape route collapsed shut behind the first group, however, the remaining hatchlings and eggs may be safe from flies, ghost crabs, and other beach predators.

Diet and Feeding

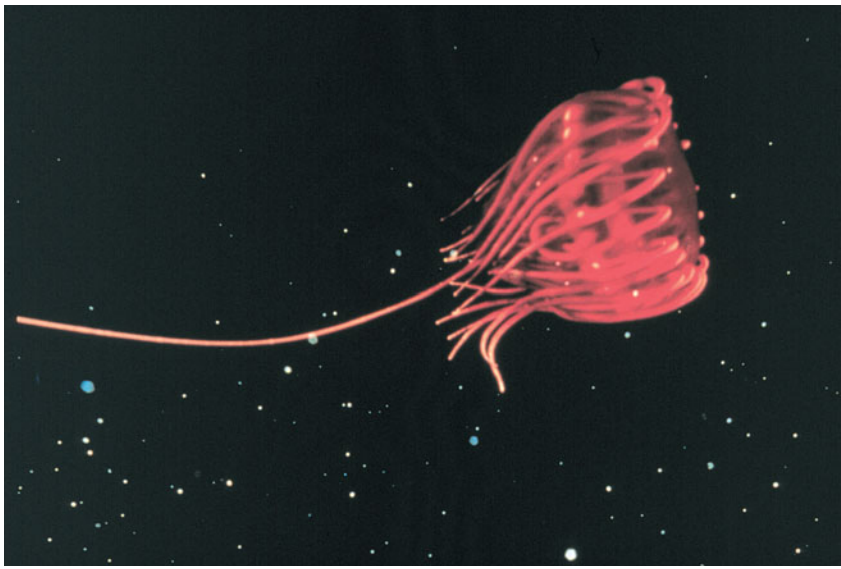
Some marine turtles have specialized diets. For example, after reaching a certain size, green turtles become herbivores and feed on sea grasses, marsh grass, eel grass, and algae, especially sea lettuce and species of the plant *Enteromorpha*. All other sea turtles are carnivorous (i.e., they eat animal matter) with varied diets. The giant leatherback specializes in soft-bodied

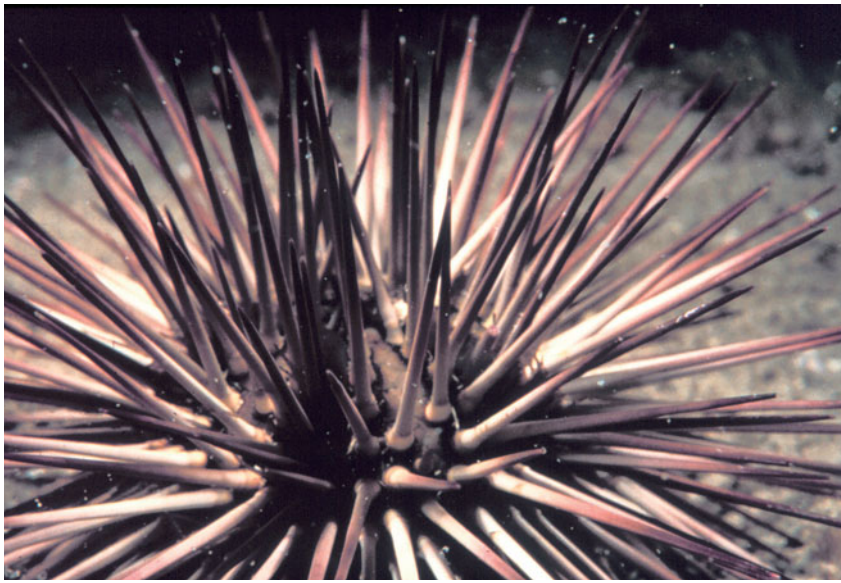
Reefs are good foraging areas for sea turtles. Courtesy of Katie Adams.

pelagic (open ocean) organisms in the water column such as jellyfish, but along with them may incidentally ingest commensal organisms such as certain crabs and other invertebrates. Hawksbills feed primarily on sponges but also eat sessile (i.e., immobile) or slow-moving invertebrates such as sea urchins. The ridleys and loggerheads have similar diets; they feed primarily on crabs and mollusks on the bottom but will also eat jellyfish.

There has been no thorough study of how carnivorous sea turtles choose, catch, or swallow their prey. Inspection of gut contents suggests that turtles may be selective both in what they catch and in what part of the organism they eat. The stomach of a turtle that feeds on whelks, for example, may contain only a handful of large opercula (an operculum is a hard structure tightly attached to the snail's foot that is used to seal the opening of the shell) and a few shell spires. The turtle presumably crunches the snails, then swallows only the soft parts and smaller shell fragments. By eliminating much of the heavy shell, the turtle reduces the load of indigestible material passing through its gut.

Plastic waste has apparently been responsible for some sea turtle deaths. A large percentage of turtles ingest plastic in one form or another while foraging. While much of the plastic passes through the gut, toxic materi-





TOP

The giant leatherback specializes in soft-bodied organisms such as jellyfish. Ridleys and loggerheads will eat them as well. Courtesy of M. Youngbluth, OAR/National Undersea Research Program, Harbor Branch Oceanographic Institution, NOAA Photo Library.

BOTTOM

Although hawksbills feed primarily on sponges, they may eat slow-moving invertebrates such as sea urchins. Courtesy of Sanctuary Collection, NOAA Photo Library.

als may leach out of it and into the turtle's body tissues. Plastic bags, when swallowed, may obstruct the turtle's gut and kill it. Tiny pieces of plastic are found in almost all samples of gut contents; they are regularly incorporated in marine worm tubes consumed by the turtles along with the worms. In prehistoric times, any object in the water was plant or animal material, so it was a wise strategy to forage opportunistically. That strategy may be hazardous today.

Disease and Parasites

Fibropapillomatosis is a debilitating disease of sea turtles in which skin tumors proliferate. When it remains external, it may heal by itself; if it invades the turtle's system, it is usually fatal. It was first seen in south Florida in the late 1930s, was found on sea turtles in Hawaii in 1958, and reappeared on the east coast of Florida in the early 1980s. Its primary victims are green turtles, but it has been diagnosed in other species as well, including loggerheads, Kemp's and olive ridleys, and leatherbacks. The disease has been found worldwide in all major oceans, primarily throughout the tropics, and the cause has not been identified. A virus may be responsible, as a herpes virus has been associated with 95 percent of the cases in Florida. In fishes, pollution stress is often associated with papillomas, suggesting that marine animals are more susceptible to virus infections when stressed, although this does not seem to be the case with the early stages of the disease in green turtles.

Internal parasites include representatives of the major groups of Platyhelminthes (flatworms), with an abundance of flukes. Three genera of blood flukes producing disease have been identified in 33 percent of the loggerheads along the East Coast. Many turtles with blood flukes appear normal, but animals with heavy parasite infections are usually emaciated, anemic, have enteritis (intestinal inflammation), and bear a heavy load of barnacles. Whether the heavy parasite infections are secondary to other debilitating factors is unknown. Most of the flatworms have been found in the gastrointestinal tract (one species is found in the urinary bladder) and are not necessarily associated with weakness. Many sea turtles infected with roundworms in the intestinal tract, especially the stomach, appear healthy and are apparently able to tolerate their presence.

External parasites occasionally include leeches, especially in the axillary regions (where the arms and legs join the body) and around the cloaca. A variety of other organisms, such as barnacles, mollusks, polychaetes, amphi-

Fibropapillomas on a green sea turtle. Courtesy of Kara Dwyer Dodge.

Barnacles, mollusks, polychaetes, amphipods, and algae—collectively known as "epibiota"—attach to the outside of the carapace. Photo by Carol Ruckdeschel.

pods, and algae—collectively known as "epibiota"—also attach to the outside of the carapace. Most of them are commensal organisms; that is, they benefit from the association, and the turtle (the host) is apparently not negatively affected. Commensal organisms are found on the carapace and skin of most species of sea turtles but are especially abundant on loggerheads. Some species of barnacles are found only on sea turtles. As long as a turtle is healthy and active, it can control the amount of epibiota living on its back by regularly scraping its back with its flippers. In addition, during growth the turtle periodically sheds the top layer of the scutes that cover its carapace, at the same time shedding many attached organisms. When a turtle becomes

inactive, the load of epibiota on the carapace increases; this may camouflage the turtle, but it also adds weight and much drag to the turtle's movement.

Predators

Because sea turtles use different habitats at different life stages and vary greatly in size during their lifetime, each sea turtle life stage has a different suite of predators. Eggs and hatchlings have the greatest variety of predators because they are small and vulnerable and occupy two very different habitats: the beach and the sea. The potential for predation is high during the night the eggs are laid, decreases during the incubation period, and rises again at the first emergence, when the scent of the hatchlings can be a cue to the location of eggs.

Ghost crabs and raccoons are the major egg and hatchling predators along the Atlantic and Gulf coasts today, but skunks, bears, wolves, and even big cats were threats at one time. Ghost crabs tunnel in the primary dunes and are permanent residents of the high beach. The size (diameter) of the open burrow indicates the size of the crab, and the tunnel may be several feet deep. Ghost crabs are predators and scavengers that normally feed on amphipods, such as sand fleas, and miscellaneous organic debris left by the tide. Turtle eggs are a resource of which they readily take advantage, burrowing directly into a nest. The mess they make in opening eggs (releasing yolk and albumen, the "white" of the egg) may contaminate the clutch and destroy many more eggs than the crabs actually consume. Crab tunnels into the nest chamber also may allow odors to escape and attract other predators as well as insects looking for a place to lay eggs. Ghost crabs can also catch and overpower hatchlings on their way down the beach to the sea. During a large emergence of hatchlings, a crab may kill many, eating only the eyes and brain before switching to another individual.

Raccoons also attack both eggs and hatchlings. A single raccoon usually returns to a clutch several times (nights) before finishing it, but a locally high population of raccoons can destroy most of the eggs laid during a nesting season. Of bears preying on sea turtle eggs along the Florida coast, Thomas Barbour wrote many years ago, "I saw their tracks on a number of occasions when they had been walking the ocean beach waiting for the loggerhead turtles to come ashore and lay their eggs." "So vigilant are the bears," wrote another observer, "that the turtle seldom leaves her nest above a quarter of an hour before the eggs are eaten." The success of reproductive

Ghost crabs are one of the major egg and hatchling predators along the Atlantic and Gulf coasts today. Photo from the Sapelo Island National Estuarine Research Reserve, NOAA Central Library.

seasons must have varied greatly from year to year in the past, and in part depended on the abundance of mammalian predators.

Most of the southeastern barrier islands have been used as game preserves and livestock farms over the past 200 or 300 years. Animals were released to fend for themselves, and, confined by the surrounding sea, were likely to be there, along with their feral offspring, when the owner returned. Hogs fared particularly well on the islands, much to the detriment of sea turtles. Once a hog has learned to recognize turtle eggs as food, it actively searches for nests and will even follow the track of a female emerging from the surf up to her nest site. Unlike a raccoon, a hog can consume several entire clutches of eggs in a single night, and if hogs are numerous, very few—if any—sea turtle eggs in an area survive to hatching that year.

Ants have become serious predators of hatchlings as exotic fire ants have expanded their range up the coasts. If a colony of fire ants discovers hatchlings slow to leave the nest, the consequences can be disastrous. Ants swarm on the hatchlings, consuming the moist eyes first. As with other predators, the likelihood of ant predation increases with the emergence of the first group of hatchlings, and if the tunnel down to the nest chamber remains open, all the remaining hatchlings may be killed by ants.

Sea turtles may be attracted to shrimp trawlers by the "bycatch," the unwanted crabs, mollusks, invertebrates, and fish that are dumped overboard when the nets are hauled aboard. The results can be deadly. Here, a hawksbill is caught in a commercial fishing net. Courtesy of Alejandro Fallabrino.

Other, usually minor, predators include opportunistic birds, such as crows, which scratch and poke to uncover eggs and hatchlings just below the surface, and may also take hatchlings that have gotten lost on their way to the sea, as well as those that may emerge during daylight. Even emergence at night does not guarantee safety from birds, because some, such as night herons, are nocturnal.

Armadillos are occasional egg predators. Armadillos may be initially attracted to fly larvae in a contaminated nest and encounter turtle eggs secondarily, but they do eat turtle eggs. They also eat various terrestrial vertebrates on occasion, so the fact that an egg contains a full-term embryo would not be a deterrent. Armadillos frequently wander and forage in the primary dunes and have extended their range northward into North Carolina. Dogs, feral or domestic, will also excavate and eat turtle eggs and are major predators in some places.

Finally, humans along the coast have probably always enjoyed turtle eggs and occasionally butchered nesting females. The remains of cheloniid turtles have been documented in Indian middens up and down the coast, and some old cake recipes specifically call for turtle eggs. On one Georgia barrier island in the 1930s, residents apparently butchered ten or twelve adult

turtles—probably loggerheads—each summer. But the main turtle selected for the international culinary trade was the green turtle.

Conservation

For centuries the seemingly limitless populations of sea turtles have been commercially exploited for their eggs, meat, oil, leather, and shell, leading to a great decline in numbers in many areas. The decline may have begun centuries ago, but sea turtle populations were in obvious trouble by 1900. Most populations have continued to decline, and all species of sea turtles are currently recognized nationally and internationally as in peril.

Present human-associated threats to sea turtles vary with geographical location and include destruction of nesting habitat, consumption of eggs, and deliberate and incidental killing of turtles in the sea. Coastal development for human use is nearly complete in the United States, and few undeveloped or unthreatened areas remain outside preserves. Besides physically obliterating the dunes in which sea turtles lay their eggs, we illuminate the coastline at night. Light in any form—flashlights, headlights, firelight, or house lights—presents a problem for sea turtles. Although in some areas they seem to adjust to lights over time, adults coming ashore to nest prefer a dark horizon to select a proper nesting site and may be frightened back to sea by bright or moving light. Adults that have completed nesting and hatchlings have the opposite response to light: they are attracted to it. Over the eons they have been able to rely on the low-intensity light reflection from the ocean to guide them back to the water. If a brighter light source is available, they may be lured to it and away from the sea. Hatchlings have been fatally attracted to beach bonfires. Fortunately for the turtles, much seafront lighting is now baffled or shielded.

Historically, undeveloped barrier island beaches have been attractive to nesting sea turtles. When such islands supported populations of feral swine, the eggs and hatchlings were largely or completely destroyed. Many barrier islands also have (or had) populations of feral cattle and horses, both of which have a negative impact on the dune system through grazing and trampling, and thus affect sea turtle nesting success. Other human-introduced threats to sea turtle reproductive success are fire ants, which kill hatchlings, and exotic vegetation, which alters the nesting environment.

Human activity has also been responsible for increased predation by native predators. For example, many sea turtle nests were once protected

ABOVE
A loggerhead entangled in gill net lines. Courtesy of National Marine Fisheries Service.

LEFT
A shrimp net with a "turtle excluder device," or TED, forces larger objects, such as sea turtles, along the angled grid until they reach the edge, where they continue on out to freedom through a flap-covered opening. Despite the use of TEDS, turtles may still die or suffer severe shock before they are passively shunted out of the trawl net. Courtesy of William Folsom, NMFS.

by the presence of alligators, which proliferated in the freshwater sloughs behind and paralleling many beaches. Dikes, dams, roads, and a great reduction in the alligator population have altered that scheme, allowing the numbers of native turtle predators to increase—so much so that they sometimes must be artificially controlled to allow successful turtle reproduction. Dogs, feral or domestic, also pose a threat when they harass a nesting female or excavate eggs.

Vehicles on beaches at night disrupt nesting and threaten hatchling sea turtles. A female may abort a nesting attempt if she spots a passing vehicle, and hatchlings may get trapped in deep wheel ruts on their way to the sea or be enticed to follow bright vehicle lights parallel to the sea, thereby increasing their exposure to predators.

Today, at the turn of the twenty-first century, efforts are being made up and down the coast to establish a few safe nesting areas for sea turtles. The land set aside is a small fraction of the turtles' once extensive habitat, and in the meantime other beaches continue to be developed and turtles continue to be killed in the sea.

Commercial fishers kill thousands of sea turtles every year. Shrimp trawls appear to be the worst offenders. The National Research Council in 1990 determined that between five thousand and fifty-five thousand sea turtles were killed annually in shrimp trawls in the United States. Other commercial fishing gear such as long-lines, gill nets, pound nets, and lobster pot lines also incidentally catch sea turtles, although precise mortality figures are lacking.

The National Marine Fisheries Service (NMFS) is the government agency in charge of protecting sea turtles when they are in the marine environment, and the U.S. Fish and Wildlife Service handles enforcement on land. The primary duty of the NMFS is to promote and protect commercial fisheries, which creates a significant conflict of interest with their concomitant mandate to protect sea turtles. In 1990, in recognition of the enormous annual mortality of sea turtles, the NMFS required all trawlers fishing in U.S. waters to install a "turtle excluder device" (TED) in their nets. The device consists of a strong metal grid with vertical bars that is placed in the lower end of the net. The bars allow small objects, such as shrimp, to pass through into the catch bag in the end, but larger objects, such as sea turtles, are forced along the angled grid by the forward motion of the net until they reach the edge, where they continue on out to freedom through a flap-covered opening in the net. The TED in its current form has severe drawbacks, how-

What to Do If You Find a Stranded Sea Turtle

The high mortality rate of sea turtles along the East Coast and Gulf of Mexico increases the chances that beach users will encounter a dead animal. Distinct characteristics identify each species of turtle. The keys provided in the Appendix will help with identification. A carcass may not be fresh or even intact, so several keys are provided based on the condition of the carcass.

All sea turtles are protected by law, and live animals and carcasses can be moved only by authorized personnel. Much biological information can be gathered from dead animals, such as distribution, seasonality, reproductive condition, diet, and health, so strandings should be reported to the nearest state or federal authority. Documenting each animal is also important to establish the magnitude of mortality.

ever, because turtles do not voluntarily exit the net that way. Turtles are prevented from reaching the surface to breathe while trapped in the net and may become comatose from lack of oxygen and either die or suffer severe shock before they are passively shunted out of the trawl net via the TED. The number of dead sea turtles washing ashore has increased since TEDs have been required, yet the government continues to support their use. The NMFS is continuing to modify the TED and TED regulations, hoping to reduce sea turtle deaths while allowing trawling to continue.

The physiological responses of sea turtles entangled or trapped underwater in fishing gear are not well understood. We do know that sea turtles are less likely to survive forced submergence than some freshwater turtles. In addition to problems caused directly by lack of oxygen, the stress that results from forced submergence results in physiological changes that can lead to irreversible shock, and animals may die hours after they seem to have recovered from the lack of oxygen. This fact may help explain why the use of TEDs in trawl nets has not reduced the enormous mortality along our coasts.

It is important to remember that the number of strandings—that is, the number of dead or dying turtles that wash ashore—is only a fraction of the number of turtles actually killed. Many carcasses are carried out to sea, eaten by sharks and other scavengers, or decay before reaching shore. Studies indicate that only 7–25 percent of the animals killed wash ashore, depending on wind direction, temperature, and other factors. Yet stranding records are the only solid data available with which to judge the effectiveness

Tracks of a loggerhead (left) and a leatherback (below). Photos by Carol Ruckdeschel and courtesy of Dr. Renata Platenberg.

of the TEDs. During the 4-year period 1998–2001, 12,646 sea turtle strandings (deaths) were documented by the NMFS along the Atlantic and Gulf coasts. The actual mortality those carcasses probably represent is 38,000 or more turtles.

Sea turtles may be attracted to trawlers by the "bycatch," the unwanted crabs, mollusks, invertebrates, and fish that are dumped overboard when the nets are hauled aboard. Only a very small percentage of the trawl catch is the target species, shrimp. In some areas, a 30-to-1 ratio of bycatch to

shrimp has been recorded. Most of the bycatch is dead when it is returned to the water. Sea turtles regard the bycatch as a free lunch and may linger in the area to feed. The situation can prove lethal when many shrimp boats are trawling in the same area. Destruction of the benthic (bottom) habitat by bottom trawling also contributes to the general degradation of the ecosystem and destroys potential foraging habitat for sea turtles and many other marine creatures.

In addition to deaths caused directly by shrimp trawls, gill nets, and other fishing gear, pollution of the marine environment is taking a toll on sea turtles. The effect of pollution and trash on sea turtles has not been measured, although abnormal loads of heavy metals have been found in sea turtle eggs in Georgia. PCBs (polychlorinated biphenyls) from swallowed plastic may accumulate in the turtles' bodies. Turtles caught by stray hooks and lines can be trapped underwater. Hooks are sometimes found imbedded in the wall of the esophagus or stomach; if they pass into the intestines they may do lethal damage. Fishing line alone can entangle a turtle and hold it underwater to drown. Line that becomes wrapped around a flipper can cause amputation, and swallowed fishing line can cause strangulation of the gut. The indirect effects on sea turtles of toxic material from coastal paper mills and toxic sediments uncovered by dredging have not been assessed.

Entrance channels along the coast are regularly dredged to permit navigation. Turtles and other animals are sometimes sucked into the cutting heads of a dredge and forced through pipes to the spoil basin or hopper. Because of the significant threat dredging poses to sea turtles, much dredging is undertaken during the cooler winter months, when most sea turtles have left the area.

Boats in inshore waters frequently collide with sea turtles and can be a cause of turtle mortality. Many carcasses each year have fresh propeller wounds, but whether the animals were alive, comatose, or dead at the time of impact in many cases remains unclear. Turtles occasionally survive collisions with boats, but with the number of boats increasing, the problem is likely to become critical.

Increasing sea turtle mortality combined with increasing development and use of coastal beaches make it more important than ever to educate people about sea turtles and their requirements. All sea turtles are protected by state and federal laws, and it is illegal to harass them or interfere with the nesting process in any way. It is possible, however, to witness the nesting process without disturbing the turtles.

Guidelines for Observing Nesting

By taking a few simple precautions it is possible to observe a nesting sea turtle without disrupting the process. Adding a red filter to a flashlight when walking on the beach at night makes the light less disturbing to the turtles. Unless there is no moonlight at all, there is usually enough natural light to see by once the eyes have adjusted, and a flashlight may not be necessary at all. Walking low on the beach near the surf line and keeping an eye out for an emerging female helps ensure that a turtle on her way up to the dunes will not be spooked. A turtle moving up the beach or already in the dunes leaves a track that can be followed without the use of a flashlight. To determine the direction of travel, look for distinct Vs made by the claws on the rear flippers; these are usually visible and point backward (opposite the direction of travel).

The sight or suggestion of a person usually causes an emerging female to abort that nesting attempt. An observer must remain unnoticed until the nesting turtle has chosen a location, wallowed down to firm sand, and begun digging the nest cavity, as evidenced by regular back-and-forth jerking movements of the turtle and the formation of a dark triangle at the rear of the carapace caused by thrown sand. Light-colored sand thrown up by the rear flippers accumulates on the front of the carapace, leaving an uncovered dark spot between the rear flippers and over the tail. Observers may gather behind the nesting animal at this time but should approach from the rear to minimize exposure. Usually, but not always, turtles seem oblivious to moderate activity around them once they begin laying eggs. A small flashlight may be held low, near the nest cavity but out of the way of the active rear flippers. At no time should lights be shown directly on a turtle's head. Doing so may impair her sensitivity to low-intensity light and affect her ability to return to the sea. When the nest excavation meets the turtle's specifications, she will begin releasing eggs.

When all shelled eggs have been expelled, the turtle will cover the nest. The process ends with a flailing of sand by the front flippers, which have up to this time been motionless. This flailing is a signal for the observers to retreat, especially if they are between the turtle and the water. Again, all lights should be extinguished so that the turtle can more easily find the water. Because sea turtles are adapted for aquatic rather than terrestrial life, locomotion on land is difficult for them. They should never be harassed by touching or by moving within their line of sight. When the turtle finally enters the water, she remains on the bottom as she swims through the surf to deeper water. Most turtles may be seen one last time on a calm night as they come up for a breath of air about 50 yards out from shore.

Those who have witnessed this ancient behavior, repeated for many millions of years by giant reptiles on beaches around the world, seldom forget the experience. Until now, the turtles' nesting behavior has been one of the most successful biological strategies known, but it will require extraordinary conservation efforts if they are to survive the era of humans.

Species Accounts

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Leatherback

Dermochelys coriacea

Dermochelyidae

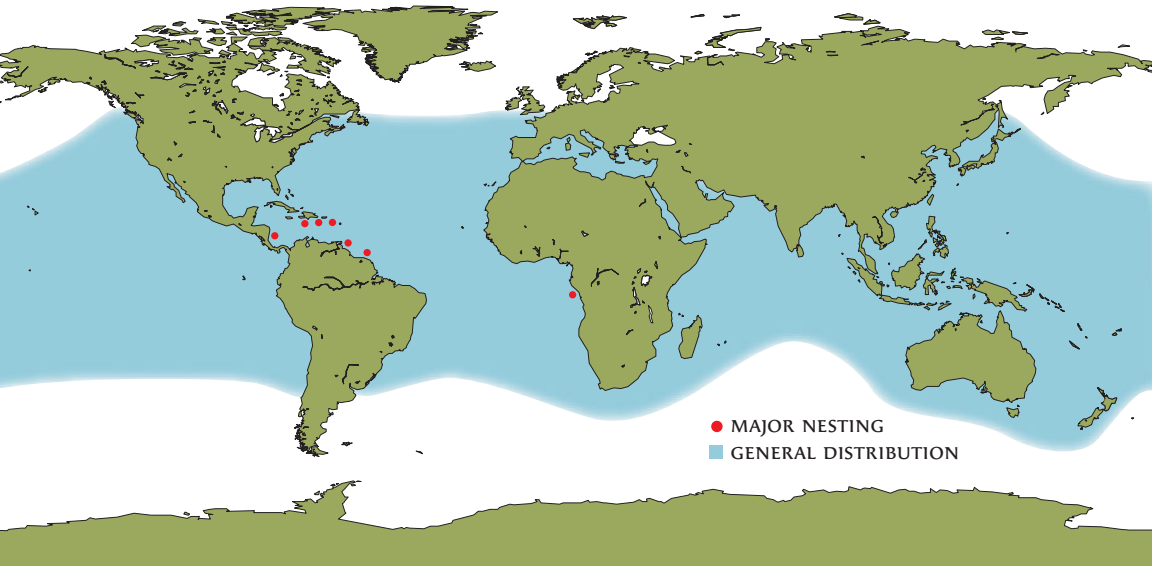
Status

National: Endangered.
International: Critically Endangered.

Leatherbacks, because of their extensive migrations and specialized food requirements, are often seen in loose groups, usually well offshore. Sometimes more than a dozen may be observed in a small area. Depending on whether they are feeding on surface-floating jellyfish or those found at great depths, leatherback sightings may be frequent or rare. In short, accurate population counts are difficult, but summer migration numbers along the northeastern coast are estimated to be in the low thousands. Such numbers are probably present at times off the southeastern coasts as well, and also in the Gulf of Mexico. Several hundred leatherbacks regularly nest on the Florida east coast, and at least one has nested as far north as Maryland, but most leatherbacks nest in tropical areas well outside the continental United States. Some tagged animals found dead on eastern U.S. shores were originally tagged in Central and South America, so it is clear that multinational protection is required if their status is to improve.

Distribution and Habitats

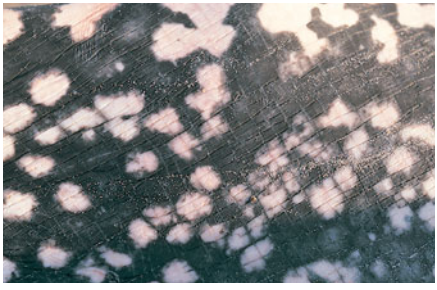
Of all the reptiles in the world, this species has the greatest geographic range. Leatherbacks are mainly tropical nesters. Major nesting areas (with more than one thousand females) are found on the Caribbean, Central and South American, and west and southwest African coasts, but a minor amount of nesting occurs in Florida. The foraging range of leatherbacks includes the Atlantic, Pacific, and Indian oceans north and south toward the Arctic and Antarctic circles.



Leatherback (*Dermochelys coriacea*)

Their physiological adaptations to cold water and great depths along with their powerful swimming abilities allow leatherbacks to wander great stretches of ocean. Aerial surveys have confirmed that some individuals may be found west of the Gulf Stream throughout much of the year. Although leatherbacks have been described as the most oceanic or pelagic of all the turtles, they may spend time foraging relatively close to shore in search of the jellyfish on which they feed. Surveys have shown almost no leatherbacks in the Gulf Stream, but groups of migrating individuals are observed in continental shelf waters in spring and fall each year; most of these are not from Florida populations. Each spring, some leatherbacks migrate north along the Gulf and Atlantic shores to locations with dense aggregations of large jellyfish. By late May leatherbacks are less common in the waters off the Southeast, but in some years individuals may be observed in the summer months. These may be females that nested on tropical beaches and were late heading north, as suggested by a stranded (dead) female examined in late summer in Rhode Island. In autumn the migration direction is reversed, and leatherbacks are sometimes seen in groups in the Gulf of Mexico. Migration routes in the Atlantic Ocean are apparently not restricted to well-defined corridors as they are in the Pacific Ocean.

Leatherbacks spend all of their juvenile years in the open ocean (in con-



TOP
A female leatherback comes ashore.
Courtesy of Alejandro Fallabrino.

MIDDLE
A female leatherback after nesting.
Courtesy of Richard Moore.

LEFT
A closeup of leatherback skin.
Photo by Carol Ruckdeschel.

The leatherback (right) is by far the largest living turtle. Note how much smaller the green sea turtle (above) is in relation to the humans. Courtesy of Asaf Senol and Suzanne Livingstone.

trast, large juvenile cheloniids return to inshore marine waters to complete their development). Essentially nothing is known of leatherback behavior from the time they enter the water as hatchlings until they near adulthood, thereby presenting one of the remaining mysteries of sea turtle biology.

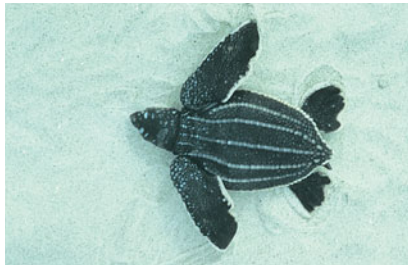
Appearance

By far the largest living turtle, the leatherback is the easiest sea turtle to identify because of its ridged, black, skin-covered shell; deeply notched, double-cusped upper jaw; and immense size. In addition, many internal features make this species unusual among turtles and contribute to leatherbacks' amazing ability to exploit the oceans and feed on a variety of soft-bodied organisms, sometimes in very cold and deep waters.

Size

Most adults reach a weight of 400–450 kilograms (900–1,000 pounds, approximately half a ton). The record size is a little over 780 kilograms (2,000 pounds). Other than hatchlings, individuals that weigh less than 125 kilograms (275 pounds) are rarely seen. About a dozen juvenile specimens less than a meter in length are known, and ten of those were found in waters

26°C (78–79°F) or above. No water temperature was recorded for the others. It appears that animals less than a meter long avoid the cooler waters often occupied by larger individuals. The shell of adults is usually more than 1.4 meters (4.6 feet) long and may reach 1.8 meters (6 feet). The enormous size of a large leatherback is difficult to imagine without actually seeing one. The body is quite thick (more than a half meter), and the shell plus head and tail are more than 2 meters long. A very large individual filled the bed of a small



Leatherback hatchlings. Courtesy of Scott A. Eckert / WILDCAT and Ana Rebeca Baragán, Kutzari A.C.

pickup truck, and the flippers reached over the truck's sides to the ground. Reflecting the size of the eggs, hatchlings are relatively large, with the carapace length ranging from 56 to 63 millimeters (2.2–2.4 inches).

Color

Although sometimes described as brownish, most leatherbacks are black, bluish black, or grayish black, often with some lighter spotting or mottling, and with lighter, sometimes pinkish, undersides. The head is spotted or mottled with bluish white and has an irregular pink blotch on the top center. The flippers are heavily flecked with bluish white, white, or pinkish spots. Hatchlings are astonishingly beautiful: the carapace is intense blue-black trimmed with white ridges and margins; there are twice as many white lines on the top of the neck as on the body; and there are a few regularly spaced white spots on the head. The plastron also has light stripes running to the rear margin with a large, light umbilicus (the indentation marking the spot where the yolk sac attached to the body of the embryo). All four limbs have light borders.

Shell

The leatherback's carapace is unlike that of any other living turtle, and its formation is fundamentally different from that of the hard-shelled turtles of the family Cheloniidae. The vertebrae and ribs of the leatherback do not fuse to form a bony carapace, but are instead integrated into an underlying fibrous cartilage layer (see Fig. 3). A bony covering of this layer is formed exclusively from membrane bone, or osteoderms. These dime- to quarter-sized interlocking or sutured polygonal bones, along with the tough, fibrous cartilage layer beneath them, form a slightly flexible protective carapace that

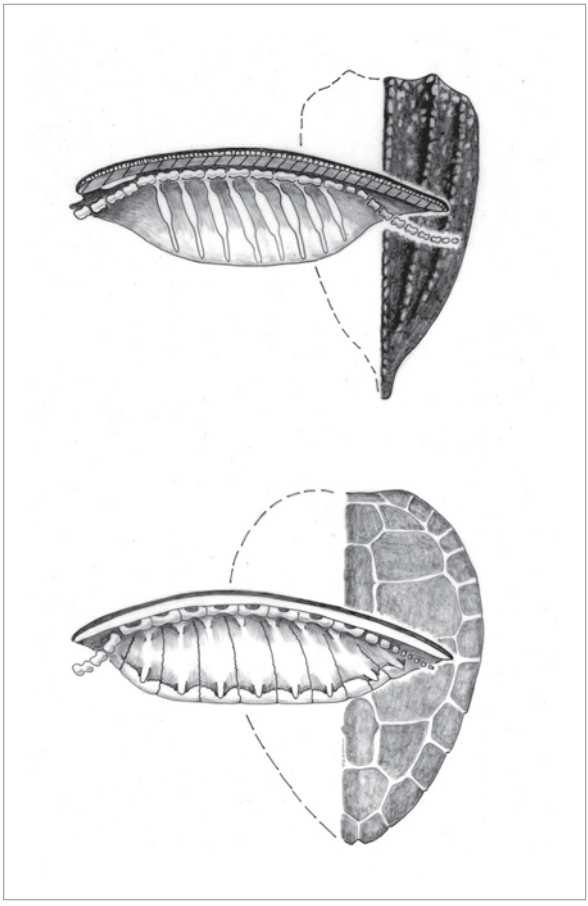


Figure 3.
The vertebrae and ribs of the leatherback (above) are integrated into an underlying fibrous cartilage layer. By contrast, the vertebrae and ribs of cheloniids (below) fuse to form a bony carapace.

suits the deep-diving habits of this species. No peripheral bones support the margin of the shell, as is the case in some turtles. The carapace has a streamlined look, with seven distinct ridges running lengthwise from near anterior to near posterior (five if the ridges along the side are not counted) and a pointed extension at the rear. A thin, smooth skin covers the carapace and plastron. The skin is easily scratched or damaged, and the surface is not oily but is smooth and sleek, and feels like rubber. Barnacles are occasionally found on leatherbacks but rarely on the skin of the limbs, neck, head, or tail.

The hatchling is initially covered with scales, but within days the scales begin to bead up; within 3 weeks some have been shed, especially on the head

TOP
Leatherback hatchlings head to the ocean.
Courtesy of Alejandro Fallabrino.

BOTTOM
Leatherback hatchlings are astonishingly beautiful.
Courtesy of Suzanne Livingstone.

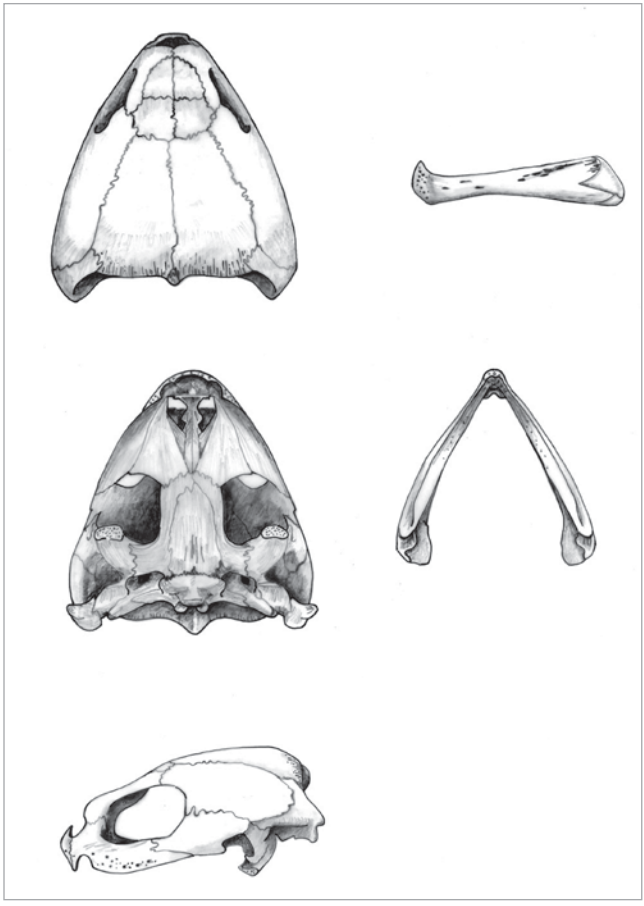


Figure 4. Skull of a leatherback sea turtle.

and flippers. By 4 weeks, most of the scales are gone and whitish spots enlarge on the anterior part of the carapace. Only a few intermediate-sized specimens are available, which makes it difficult to generalize about pattern and developmental changes. If the animals could be kept in captivity for more than a few months, perhaps additional changes could be documented, but they do not survive well in captivity.

Head

The head is relatively small for such a large turtle and has a deeply notched upper beak. The beak, or rhamphotheca, is shiny black and knife-edged. The notch in the sharp beak is clearly visible on the skull as well (see Fig. 4).

The flippers of the leatherback hatchling (top) are proportionately wider and longer than those of hard-shelled turtles such as the loggerhead hatchling (bottom). Courtesy of Chris Johnson and Tony Cocco.

Limbs and Tail

The flippers are massive, proportionately wider and longer than those of hard-shelled turtles, and have no claws. The tail is flattened laterally and in males is proportionately shorter than in males of other species. The front flippers of hatchlings reach back to the hind feet.

Life History and Behavior

Special Adaptations and Traits

Leatherbacks are unique in many ways besides size and shape. They can dive to depths rarely reached by any other air-breathing vertebrates except perhaps sperm whales and possibly some seals. Such dives, to depths of more than 1,000 meters (more than half a mile), are primarily made to feed on prey in deep ocean layers. Leatherbacks have a number of special adaptations that enable them to handle the high pressure and low temperature at such depths, along with the potential problem of gas bubble formation in the blood during rapid ascents. During deep dives the lungs are fully collapsed and the flexible body may be compressed. The arrangement of the blood vessels allows blood flow to be reduced to less critical tissues, thus conserving oxygen. The leatherback's ability to tolerate the lactic acid that accumulates in the tissues as a result of anaerobic respiration is apparently limited, so dives cannot last for extremely long periods.

Leatherbacks also have a countercurrent heat exchange system in the limbs that conserves body heat. This tight network of blood vessels transfers heat from arterial blood flowing into the limbs to the veins returning from the limbs before it can be lost, allowing the limbs to remain cool while the core temperature is kept well above the ambient water temperature. If overheating is the problem, the system works in reverse, dumping excess heat into the limbs and cooling the body core. The leatherback's great bulk and the insulating qualities of large amounts of oil in the connective tissue beneath the epidermis help to retain body heat as well. Observations during aerial surveys suggest that leatherbacks may raise their body temperature by basking at the surface while slowly swimming. Such behavior, along with their dark color, which absorbs the sun's heat, may also help leatherbacks exploit the cold waters where their food is abundant.

Leatherbacks characteristically breathe differently than other turtles do. After diving, the turtle resurfaces at an angle and seems to burst upward,

then lurches forward as the body settles back level with the surface with the head again below the surface. The head is then raised above the surface and air expired and inhaled. Whether air is expelled during or before the original breaching is unknown, but this stereotyped behavior has been observed from low-flying aircraft and during a successful resuscitation of a leatherback. The resuscitated animal could not raise its head to breathe, so divers lifted it each time it surged to the surface, and eventually the animal was able to function on its own.

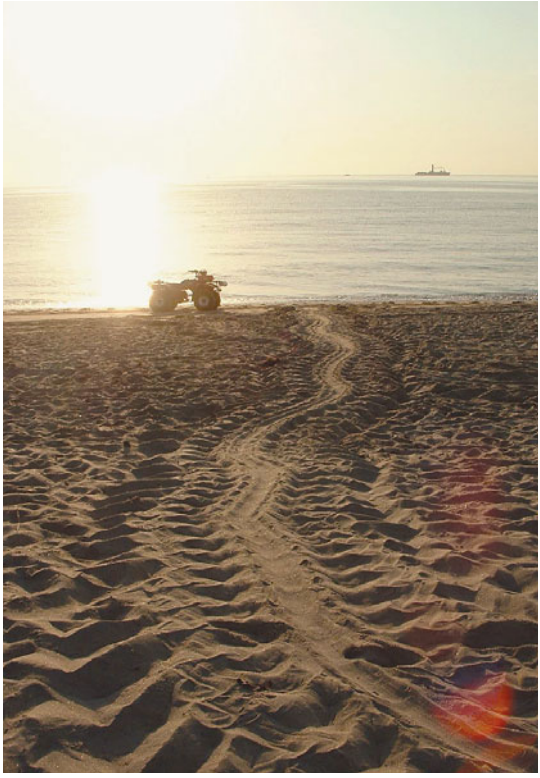
Unlike other hatchling sea turtles, little leatherbacks are able to dive and remain well below the surface immediately after entering the water.

Diet and Feeding

Leatherbacks normally feed extensively on jellyfish, salps, and other floating soft-bodied invertebrates, and may incidentally ingest other organisms associated with their usual food items, such as crabs. Fishes were found in the esophagus of a large adult killed in a trawl net off southern New England, so the leatherback must be considered an opportunist willing to take advantage of available resources. Likely the fishes were in the net when they were eaten. One autumn day, nineteen leatherbacks were observed feeding on lion-maned jellyfish while flocks of seabirds circling the area dived and fed on the jellyfish fragments that escaped the turtles' mouths. In southern waters leatherbacks eat jellyballs, which are seasonally common in the area. Jellyfish might seem inadequate to provide a giant turtle with sufficient energy, but it is important to remember that most animals are mainly water, and that jellyfish are easily caught and digested. Concentrations of leatherbacks are often found along with huge ocean sunfishes, which have similar feeding preferences.

The mouth and esophagus of the leatherback and other sea turtle species are lined with sharp, keratinous spines or papillae that point toward the stomach and perhaps act as a straining device keeping the food inside when seawater is expelled following ingestion of prey. Unlike other sea turtles, the leatherback has an enormous esophagus that extends the length of the body cavity and back up to the stomach; it serves as a storage organ since the stomach has very limited space. The rest of the tubular digestive tract has a small lumen (internal space) and a thick, muscular wall to move the primarily fluid contents.

Plastics have been reported to block the movement of food and to cause



TOP
The mouth and esophagus of the leatherback and other sea turtle species are lined with sharp, keratinous spines or papillae. Courtesy of the Karumbe Project.

LEFT
The wide tracks made by nesting leatherbacks show simultaneous movement of the flippers and often include circles. Courtesy of Tony Cocco.

death in leatherbacks, which indiscriminately swallow soft, floating objects. In the days before humans it was probably a safe feeding strategy to eat anything floating that was not wood, but nowadays the likelihood of consuming dangerous items is much increased. It has caused the death of many marine animals in addition to leatherbacks.

Growth

Recent aging studies using sclerotic ossicles (the bones supporting the eye) have suggested an average time to maturity of 12–13 years, an extremely rapid growth rate for sea turtles. Such rapid growth combined with the leatherback's pelagic existence make the likelihood of finding a small juvenile quite low. In the case of leatherbacks, large animals are not necessarily old animals.

Nesting

Most nesting takes place on tropical beaches, especially those with a steep slope maintained by large swells and waves. A few hundred individuals may nest in Florida each year, with occasional nesting north of Florida beginning a little earlier in the season than loggerhead nesting. In Georgia, leatherback nesting begins in April. There are scattered nesting records from localities as far north as Maryland. The wide tracks made by nesting leatherbacks show simultaneous movement of the flippers and often include circles created as the huge female pulls herself up the beach. The tips of the flippers arch out and leave a series of small tic marks outside the main crawl track, allowing quick identification of leatherback crawls. The pattern of nesting behavior is similar to that of other sea turtles except that leatherbacks give a double flick of sand forward off the hind foot that is preparing to make the next excavation, and during egg-laying the hind feet are held over the tail to protect the dropping eggs.

Eggs, Incubation, and Hatchlings

After excavating the nest chamber, the female lays about 85 eggs (range: 58–160), somewhat fewer than other sea turtles of the United States. The eggs measure 50–59 millimeters (average 53 millimeters; or 1.9–2.3 inches, average 2 inches) in diameter and are the largest turtle eggs. Many small, yolkless "eggs" (shelled albumin) or dumbbell-shaped eggs (two regular-sized eggs joined at one narrow point) are also typically present. The value of the yolkless, fluid-filled shells is unknown. Perhaps they supply moisture

LEFT
A juvenile leatherback. Courtesy of Chris Mather.

BOTTOM
The head of a leatherback is spotted or mottled with bluish white. Courtesy of Alejandro Fallabrino.

needed by developing embryos in adjacent eggs; or they may space the normal eggs properly for gas and moisture exchange, which takes place through the shell. That such irregular "eggs" are a standard feature of leatherback clutches suggests some selective advantage. Other species occasionally lay shelled albumin, but this trait is most developed in leatherbacks.

Adult females nest every 9–11 days (range 7–13) during a nesting season, and nest up to six or seven times a season; the record number of nestings by a female in one season is thirteen. Females normally skip a year or two

between reproductive seasons. Sometimes an individual female will nest on widely separated beaches, so nest site fidelity may not be strong in some females. Along the Pacific shores of Costa Rica, the temperature-determined sex ratio is biased toward females; this has been found to be the case for other sea turtle species as well.

Incubation takes between 56 and 72 days. A single clutch reported from Cumberland Island, Georgia, took 98 days until the first emergence, perhaps as a result of nest location low on the beach and low April and May incubation temperatures. Such a long time to emergence is unusual.

Parasites, Disease, and Predators

Leatherbacks do not accumulate epibiota as the hard-shelled turtles do, but occasional individuals have a few barnacles attached. Like other large marine animals leatherbacks sometimes carry remoras (small fish specialized to attach themselves to moving objects); several have been seen hitching a ride on a turtle at one time. Internal parasites identified include trematodes and nematodes. A nesting female along the Pacific coast of Mexico had a fibropapilloma in regression, which suggests that disease might cause some mortality in that area. Predators on leatherback eggs and hatchlings are similar to those of other species and include ghost crabs, ants, and feral animals, and outside the United States may also include monitor lizards, jaguars, and tigers. In the sea, large sharks and killer whales are potential hazards.

Conservation

By spending much of their time in deep water leatherbacks avoid many shallow-water commercial net fishery operations, yet hundreds may be killed along the Atlantic and Gulf coasts each year. National Marine Fisheries Service records from 1998 through 2001 report 428 leatherbacks found dead (stranded) along the Gulf and East coasts during that time. That number must be multiplied by four to get a conservative estimate of the actual mortality (1,712). Several state departments of natural resources have conducted aerial surveys during leatherback migration periods and have enacted temporary regulations and closures to ensure minimal impact from fishing operations in state waters. Leatherbacks are occasionally caught in pound nets (traps) but are usually released alive. They are also vulnerable

to capture by pelagic long-line fisheries and to entanglement in lobster and crab pot lines.

Ingesting plastic bags has been reported as the primary cause of death in leatherbacks in some northeastern waters.

Selected Reference

Pritchard, P. C. H. 1971. *The Leatherback or Leathery Turtle,* Dermochelys coriacea. IUCN Monograph No. 1. 39 pp.

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Loggerhead

Caretta caretta

Cheloniidae

Status

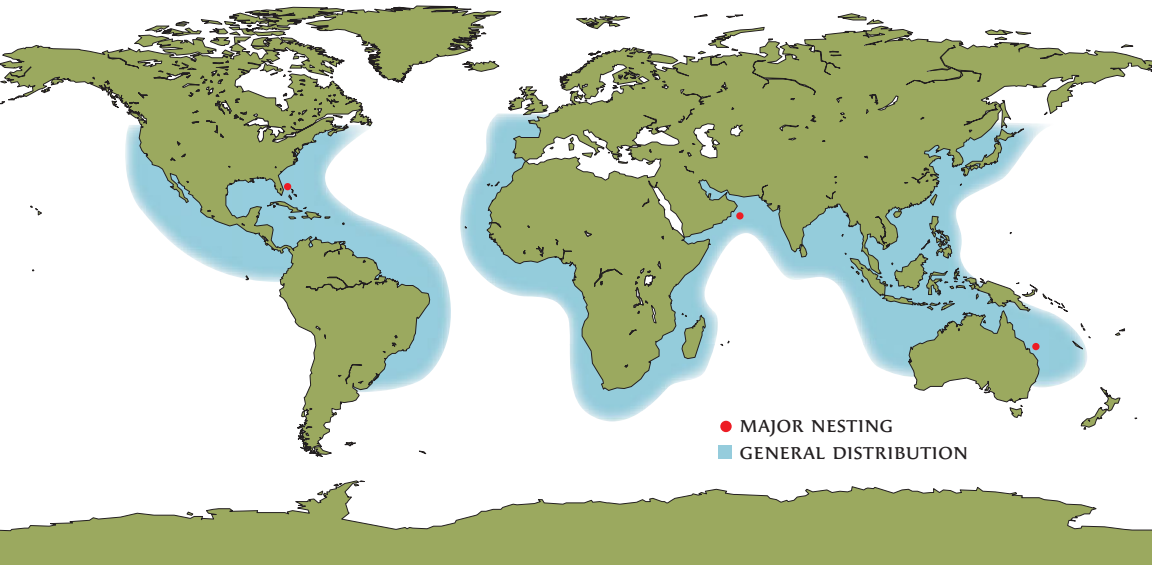
National: Threatened.
International: Endangered.

Loggerheads are the most abundant sea turtles along the Atlantic and Gulf coasts of the United States south of Cape Cod. When the species was listed under the Endangered Species Act in 1978, genetically distinct subpopulations were unknown. DNA studies have now identified at least three Atlantic and Gulf nesting subpopulations whose status must be individually assessed. The northern subpopulation nests from North Carolina south to northeastern Florida and shows a continual slow decline in numbers. The south Florida subpopulation nests from New Smyrna Beach on the east coast around to Sarasota on the west coast; it is the largest nesting population in the Atlantic and one of only two large nesting populations in the world. The amount of nesting in that area is stable overall. A smaller subpopulation occurs in the vicinity of Eglin Air Force Base and around Panama City in the Florida Panhandle, and its status has not been determined.

The other geographic area outstanding for having large numbers of nesting loggerheads is Oman, along the southeast margin of Saudi Arabia. Each of the two areas has an estimated 20,000–25,000 loggerhead nests annually.

Distribution and Habitats

Loggerheads are found in warm-temperate to tropical regions of the Atlantic, Pacific, and Indian oceans. Along the western Atlantic coast, loggerheads range as far north as Newfoundland during the warm months. Along the eastern Atlantic shore, juveniles are known from Ireland and the British



Loggerhead (*Caretta caretta*)

Isles south. No nesting takes place on the European Atlantic coast, and little takes place in the Caribbean, although there is a significant amount of nesting around the Yucatán Peninsula in Mexico.

Hatchlings and small juveniles (up to about 40 centimeters, 15.7 inches) are pelagic. Once in the sea off the U.S. coast, hatchlings use wave direction and the earth's magnetic field to direct them eastward to the giant ocean gyre and the Sargasso Sea, where they spend their early years. They find refuge at convergence zones where converging currents bring floating vegetation and debris together, forming a biologically rich community that offers shelter and food. Small juveniles (about 20–40 centimeters, 8–16 inches) are most frequently recorded in European and African waters while larger juveniles are found in U.S. waters. Small loggerheads are occasionally found along the New England coast.

Juveniles return to U.S. coastal waters at carapace lengths of about 45–50 centimeters (17–20 inches) when they are probably 7–12 years old, and complete their development in inshore waters. They reside mainly in the near-shore waters 2–50 meters (about 6–160 feet) deep and are rarely seen in water below 10°C (50°F). Both juvenile and adult loggerheads occur seasonally along the U.S. East Coast from May through October, migrating northward in the spring, frequently as far as the southern New England

coast and sometimes into Canadian waters. Physiologically, loggerheads are not adapted to hibernate the 5 or more months that would be required at northern latitudes, and their ability to remain submerged for days or weeks in hibernation remains unconfirmed. Satellite tracking studies have shown that turtles in northern waters head south in autumn along the Atlantic coast, and those in southern or Gulf waters remain there and take advantage of the abundant food resources in bays, inlets, and lagoons. Many juveniles reside in the western Gulf of Mexico year-round, and many are found in the eastern part of the Gulf mainly during spring and summer. A portion of the U.S. loggerhead population appears to be resident in Florida waters.

The major U.S. loggerhead nesting area is along the Atlantic coast of Florida, with smaller populations regularly nesting north to North Carolina, and along the Gulf coast of Florida. There is little nesting west along the Gulf coast. Along the southern East Coast, nesting females spend time in habitats up to 20 kilometers (12 miles) offshore, including natural limestone outcrops known as live bottoms, shipwrecks, artificial reef complexes, and ship channels. Adult females killed during their nesting season have little food in their gastrointestinal tracts, suggesting that they use these areas for protection and isolation rather than feeding between nesting events.

Juvenile and adult loggerheads in inshore waters spend about 80–95 percent of their time submerged, either resting, foraging, and feeding at or near the bottom or in transit from the bottom to the surface to breathe. During the day much of their time underwater is spent foraging. At night they sleep on the bottom, surfacing periodically to breathe. A large number of loggerheads observed near Cape Hatteras, North Carolina, appeared frequently on the surface to breathe between 8:15 and 8:45 A.M. This suggests that they were all responding to similar cues to begin the day. Some loggerheads rest or float at the surface in an activity referred to as "pelagic basking."

Appearance

Size

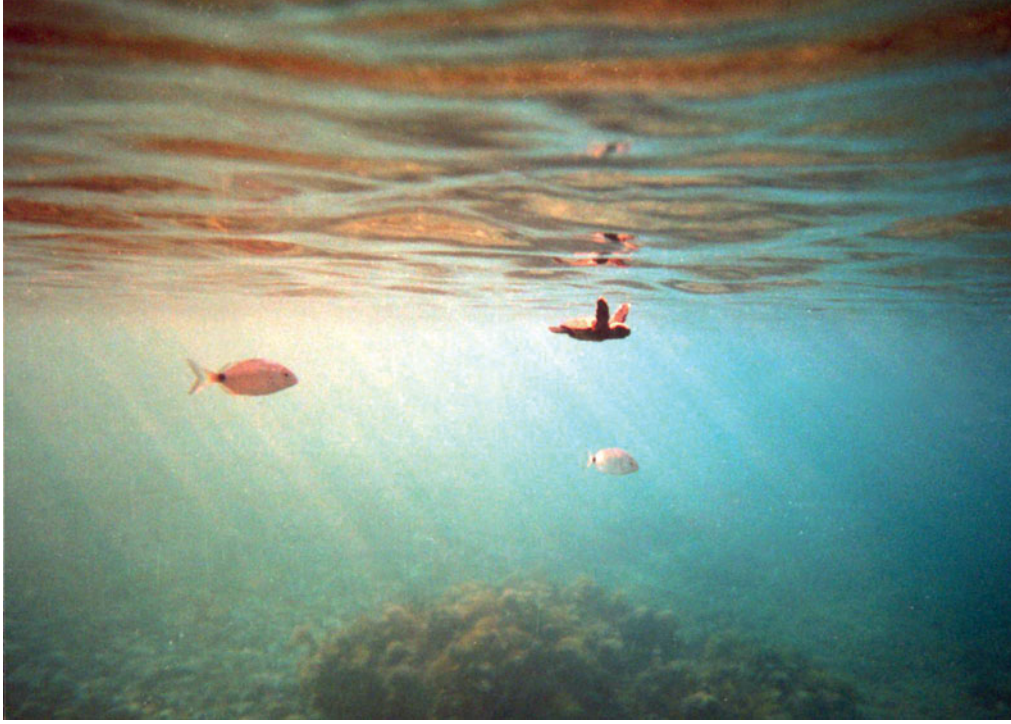
Hatchlings range from 34 to 52 millimeters (1.3–2.0 inches) in carapace length, averaging 46 millimeters (almost 2 inches), and weigh about 22 grams (less than an ounce). Adults are usually 85–123 centimeters (33–48 inches) long. Weight is variable depending on health and reproductive state, but may be up to 160 kilograms (350 pounds).

Loggerheads in inshore waters spend much of their time submerged, resting, foraging, and feeding at or near the bottom. Courtesy of Alan F. Rees / ARCHELON.

Color

The hatchling has a dark, sometimes nearly black, carapace, although there is much variation; light, rust-colored individuals are also seen. The plastron is usually lighter in color than the carapace. White (albino) hatchlings do occur, but they often have developmental problems that make them less likely to survive and reproduce. The margins of the carapace and the dorsal (upper) surface of the limbs are usually light, sometimes rusty brown.

Most juvenile and adult loggerheads have a rich rufous or reddish brown color that is a distinctive characteristic for the species. The carapace is various shades of reddish brown, as are the upper surfaces of the head and limbs, and the scales may have a colorful yellow border. Sometimes the dorsal surface of the limbs and neck is almost black. Exfoliation of the carapace scutes has an effect on the coloration. Juveniles that have recently shed a layer of scutes are noticeably lighter and brighter than those that have not. The underside of the head, neck, and limbs is pale yellow, and the plastron is pale yellow to light orange.



A loggerhead hatchling swimming. Courtesy of Trisha Page.

Shell

Characteristically, the nuchal scute abuts the first vertebral scute and the first left and right costal scutes. No marginal scutes touch the first vertebral scute, but the first, second, and usually third marginal scutes touch the first costal scute (see Fig. 5, p. 58, and Fig. 11, p. 110). The vertebral and costal scutes usually abut one another, and an occasional loggerhead has slightly overlapping costal scutes; that is, the posterior (rear) edge of one overlaps the anterior (forward) edge of the next. The rear carapace margin is smooth or occasionally slightly serrated (toothed) in adults and is deeply serrated in hatchlings, with juveniles intermediate.

Since identification is partially based on the number of carapace scutes, it is important to remember both that there is individual variability in that number and where the variability is most likely to occur. The most common scute pattern found on 437 loggerheads stranded on Cumberland Island, Georgia, was 5 vertebrals, 5L/5R costals, and 13L/13R marginals (63 percent). Fifteen percent of the animals had 12 marginals on each side, and 12 percent

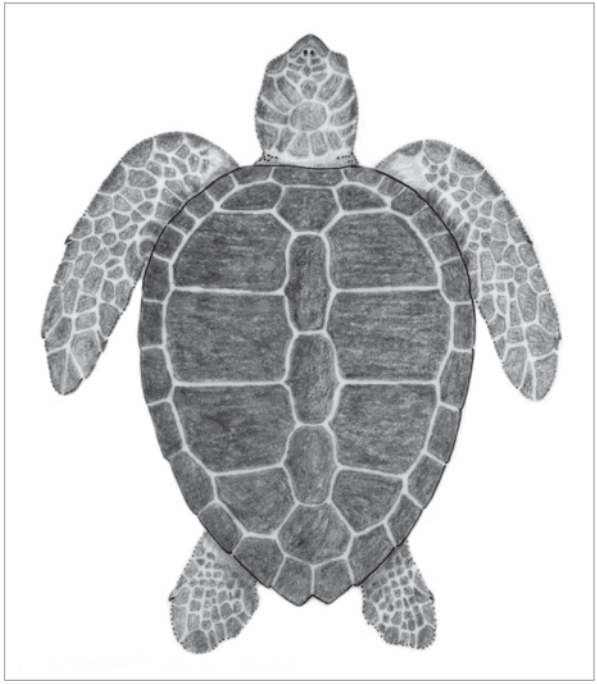


Figure 5. The carapace scute arrangement on a loggerhead sea turtle.

had 12 marginals on one side and 13 on the other. Together, these patterns were represented on 90 percent of the loggerheads. The most common deviation (5 percent) was an increase of 1 or more vertebral scutes. Irregularities in costal scutes were less frequent, with only 4.5 percent of the carcasses having unequal numbers or equal numbers, but not 5L/5R. Adults showed the same pattern and deviation as juveniles.

Hatchlings have prominent rear-pointing peaks, or keels, on the vertebral and costal scutes. These form three broken rows running lengthwise on the carapace and may aid in directional stabilization. Juveniles sometimes have reduced keels, and the keels disappear entirely well before maturity.

The plastron has six pairs of scutes, with the first five pairs roughly equal in size and shape. Hatchlings have two low ridges running lengthwise that disappear with age. The bridge has three (sometimes four) large inframarginal scutes without pores on each side.

Head

The head is covered by an orderly arrangement of enlarged scales on the top and sides. The area between the nostrils and eyes almost always bears

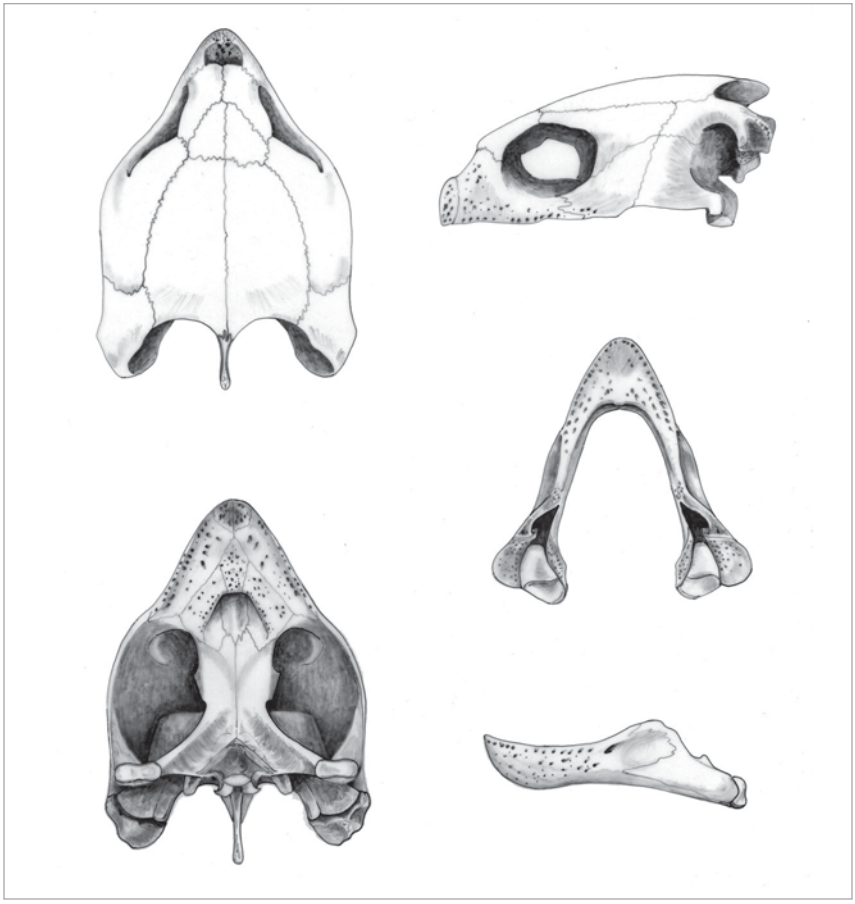


Figure 6. Skull of a loggerhead sea turtle.

two pairs of prefrontal scales followed by a row of three scales between the eyes. Usually the eye is bordered to the rear by three postorbital scales. The inframandibular scale pattern of the loggerhead and the ridleys differs, as does the shape of the ventral edge of the lower beak covering. As adults, loggerheads have proportionately larger heads than other sea turtles, and this is the source of their common name (see Fig. 6, above, and Figs. 13 and 20, appendix).

Limbs

The forelimbs, or flippers, from elbow to tip are about one-half the length of the carapace and are covered with moderately large scales outlining the un-

The loggerhead hatchling has a dark, sometimes nearly black, carapace, although there is much variation. The margins of the carapace and the dorsal (upper) surface of the limbs are usually light, sometimes rusty brown. Photos by Carol Ruckdeschel and courtesy of the Georgia Department of Natural Resources and Richard Moore.

derlying bones. Each flipper bears two claws on the leading edge. On adult males the claw on the first digit is enlarged and strongly curved; it is short and almost straight on juveniles and females. The scales on the tips and trailing edges of the front flippers are thickly keratinized and have sharp edges; they are used as scrapers to clean the shell and rid it of attaching organisms such as barnacles. Animals with damaged flippers are usually unable to adequately clean their shells and carry a heavier than normal load of epibiota.

TOP
The head of the loggerhead is covered by an orderly arrangement of enlarged scales on the top and sides. The thick rhamphotheca, or beak, enables the turtle to crush large mollusk shells. Courtesy of Alejandro Fallabrino and NOAA, NERR collection.

BOTTOM
Most juvenile and adult loggerheads have a rich rufous or reddish brown color that is a distinctive characteristic for the species. The underside of the head, neck, and limbs is pale yellow, and the plastron is pale yellow to light orange. Photo by Carol Ruckdeschel.

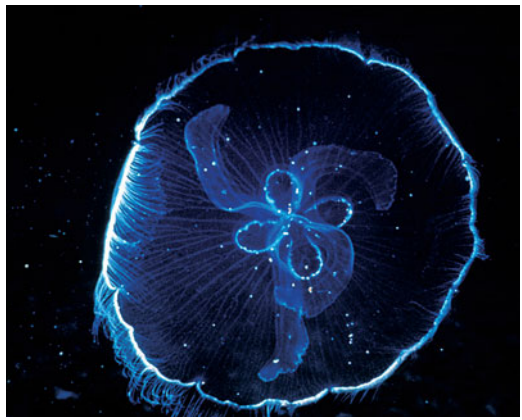
Life History and Behavior

Special Adaptations and Traits

The rhamphotheca, or beak, of the adult loggerhead is extremely thick, and combined with the broad head and heavy jaw muscles enables the turtle to crush large mollusk shells. Pieces of shell may be found wedged into the crushing surface but rarely penetrate it very deeply.

Diet and Feeding

Loggerheads are carnivores (i.e., they eat primarily animal material) their entire lives. During their first few years after hatching, which are spent at convergence zones in the open ocean, they feed on various suitably sized invertebrates such as small crabs. Terrestrial insects blown out to sea have also been found in the gut contents of pelagic hatchlings, suggesting that hatchlings are fairly opportunistic feeders.



Loggerheads shift their diet in relation to their location and the availability of prey. Individuals in the open ocean may feed on floating or near-surface invertebrates such as medusae, salps, and jellyfish. Courtesy of NOAA, Florida Keys National Marine Sanctuary.

Medium to large juveniles and adults have a broader diet and are also opportunistic. Individuals in the open ocean may feed on floating or near-surface invertebrates such as medusae, salps, jellyfish, and the barnacles—especially gooseneck barnacles—that frequently cover floating objects.

In relatively shallow shelf waters the loggerhead's primary diet is crabs and mollusks. Spider, calico, purse, lady, speckled, and hermit crabs are among the most commonly eaten crabs along the southern and Gulf coastlines. The most commonly eaten mollusks are moon snails and all sizes of whelks, including those with large, thick shells. Loggerheads avoid swallowing most of the heavy shell when consuming a large snail. Any hard material they do swallow, such as the operculum, passes on through the gut. Soft-bodied invertebrates consumed in shallow water include sea squirts, anemones, gorgonians, sea cucumbers, and marine worms. Loggerheads also feed on invertebrates living in soft bottom sediments, scraping away the sand or mud to get to them. Loggerheads shift their diet in relation to their location and the availability of prey. In the Chesapeake Bay, for example, horseshoe crabs and blue crabs constitute a large portion of the diet, while farther to the south those species are less important.

Along the U.S. coastline, trawler bycatch may form part of the diet, and the occurrence of some food items, particularly fast-swimming fish, in sea turtle stomach contents may be more a reflection of bycatch composition than natural food choices by the turtles. Infrequently, a necropsy may reveal that a loggerhead has fed on many small fish, but it is unlikely that the turtle captured so many fish while they were alive.

Female loggerheads move on land by alternate use of opposite limbs, and this is mirrored in their tracks. Courtesy of the Georgia Department of Natural Resources.

Growth

Growth is rapid during the early years and then slows as animals reach maturity. After the adult size is reached (for most, greater than 85 centimeters, or 33.5 inches), growth stalls. Some animals do not mature until they are much larger than 85 centimeters. The head probably continues to broaden with age. There are skulls in museum collections that are much larger and broader than those regularly seen today along the East Coast. Sexual maturity is reached between 20 and 30 years of age. The sex ratio for juveniles is roughly two females to every male; it has not been determined for adults.

Nesting

Mating occurs during the spring prior to nesting. Copulation commonly lasts 0.5–2 hours. Mating behavior is infrequently seen, but observations suggest that a female may copulate several times and with several males prior to the first nesting. A single early mating may provide sperm for several clutches of eggs. One loggerhead that had laid a full clutch of eggs only

Hatchling loggerheads have three prominent keels on the vertebral and costal scutes of the carapace that disappear with age. Courtesy of the Georgia Department of Natural Resources.

two nights earlier contained thinly shelled eggs when necropsied, demonstrating that females begin preparing to lay the next clutch shortly after a clutch has been laid.

Egg-laying generally occurs between April and September along the East and Gulf coasts. Successful incubation requires warm sand temperatures, so the nesting season varies with geographical location. The nesting season in North Carolina is of shorter duration and begins later than that in Florida. The nesting season for Georgia is May–mid-August, with hatching sometimes continuing on into November.

Female loggerheads skip a year or more between nesting seasons. Males may (or may not) reproduce every year, which would effectively render the functional sex ratio (the number of adults sexually active in a given season) closer to one-to-one. Females nest an average of two to three times per nesting season but have been recorded as making as many as seven nests in a single year. The interval between nestings is slightly less than 2 weeks. The incubation period varies with temperature but is normally between 50 and 75 days. Mid-season clutches usually require less time to hatch and

emerge because sand temperatures are warmer. Most loggerheads show fairly strong nest site fidelity. They may return to the same stretch of beach for each within-season nest and again after a 2-year or more interval.

Adult females emerge independently from the sea at night and nest in or near the dunes immediately behind the open beach. The event takes about 45–90 minutes under normal circumstances. If the sand is wet and thus hard-surfaced, the female, unable to judge the suitability of nesting sites, is likely to return to the water without nesting. At other times most turtles go about their business in a direct manner, traversing the beach in more-or-less straight lines.

If she encounters artificial light while emerging from the sea, a frightened female will usually abort the nesting attempt. The fact that nesting continues in some well-developed areas indicates that strong nest site fidelity may override that fear. After nesting, the female is attracted to light (under natural conditions the sea would be the lightest area).

Female loggerheads move on land by alternate use of opposite limbs, and this is mirrored in their tracks. The nest chamber is dug by alternate use of the hind limbs, which are positioned on each side of the nest cavity during egg-laying. The tips of the rear feet curl upward with the release of each egg or group of eggs.

Eggs, Incubation, and Hatchlings

The usual loggerhead clutch numbers about 110 eggs (range: 47–186), although clutches of less than 50 eggs have been observed. A small clutch may be the last a female lays in a particular season, or it may reflect disturbance of the nesting turtle. The eggs are spherical, white, and have leathery shells. Their diameter ranges from 35 to 55 millimeters (1.4–2.2 inches) and averages 40.9 millimeters (1.6 inches). Clutches occasionally include pea-sized, yolkless "eggs" (shelled albumin) or dumbbell-shaped eggs (two regular-sized eggs joined at one narrow point).

The time between hatching and emergence from the nest is about 4 days. In Georgia, hatchlings emerge in groups over a period of several days, with the first emergence usually being the largest. Hatchlings usually emerge at night, cued by cooler sand temperatures. Sometimes rain in the late afternoon causes the sand to cool prematurely and promotes a daytime emergence. Reproductive success may fluctuate dramatically depending on weather conditions and the abundance of local predators.

Parasites, Disease, and Predators

A wide variety of parasites utilize the loggerhead as a host, including cestodes, nematodes, and trematodes. One researcher found blood flukes in 33 percent of forty-three loggerheads examined along the East Coast and speculated that such infections might be responsible for significant debilitation and mortality. That is a small sample, however, and the relative impact of parasites on the species is not known. Leeches occasionally parasitize loggerheads along the East Coast. The turtles may control them by visiting special marine cleaning stations where small fish cluster to feed on the external parasites of visitors. Commensal species that attach to the carapaces of loggerheads include barnacles, bivalves, gastropods, hydrozoans, polychaete worms, amphipods, and several species of algae. Weakened animals tend to have more epibiota than healthy, active turtles.

Many species of fish are known to eat hatchlings and juveniles, and large sharks are capable of taking even adult loggerheads. Raccoons and ghost crabs are probably the most important terrestrial predators of loggerhead eggs and hatchlings today. Other predators include rats, foxes, coyotes, crows, ants (especially introduced species of fire ants), and bears. Historically, when alligators were much more abundant near nesting areas and would have limited beach access for smaller predators such as raccoons, bears were probably more important turtle predators along the East Coast than raccoons.

Feral animals such as dogs and hogs have had a major impact on loggerhead reproductive success over the last 200–300 years. On Cumberland Island, Georgia, in the early 1970s feral hogs were so abundant that it is unlikely that a single loggerhead nest survived the season, and that scenario may have been repeated for many decades on many islands where hogs were introduced.

Conservation

Loggerhead meat is considered less desirable than that of green turtles, but many have been slaughtered for food and for their leather. A Sapelo Island, Georgia, resident said that after World War II, people living on that island were allowed to take all the turtles they wanted but were asked to leave the remains behind the dunes rather than on the beach. Apparently they sometimes took ten or twelve adult turtles in a summer. Many older local fishermen said they ate loggerheads whenever they caught them. Bahamian na-

tives ate loggerheads, greens, and hawksbills indiscriminately, but for foreign markets greens were preferred.

Although it is now illegal to sell them, there was once a market for loggerhead eggs as well. One morning in the 1880s, according to an unpublished memoir written by the innkeeper's daughter, "hundreds of eggs" were brought to the hotel on the north end of Cumberland Island along with six large turtles, probably loggerheads, which were butchered. A resident of the same island recalled that his father used to take a wagon out to the beach in the 1940s and get ten to fifteen sacks of turtle eggs, which would then be taken to Brunswick, Georgia, and sold.

Light pollution is a problem for all turtles along the U.S. coasts. Many areas have laws that require oceanfront lights to be shielded, but lights still interrupt the direct route of hatchlings to the sea. The trawlers that anchor off the Georgia coast for the night often have very bright lights high above the decks that could attract hatchlings. Large predatory fish attracted to lights by the concentration of insects and small fishes could have a tremendous impact on the number of passing hatchlings.

Thousands of loggerheads are incidentally killed each year by commercial fishing operations, including gill nets, long-lines, and trawling, and there seems to be no relief in sight. Turtle excluder devices installed on trawls to meet turtle-protection regulations seem not to have reduced mortality. Commercial trawling continues while the number of dead turtles washing up along the shore continues to climb. National Marine Fisheries Service data show 7,298 strandings (deaths) on the Atlantic and Gulf coasts for the 4-year period 1998–2001. Those strandings represent nearly 22,000 loggerhead sea turtle deaths if the carcasses that never wash ashore and are not reported are estimated.

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Kemp's Ridley

Lepidochelys kempii

Cheloniidae

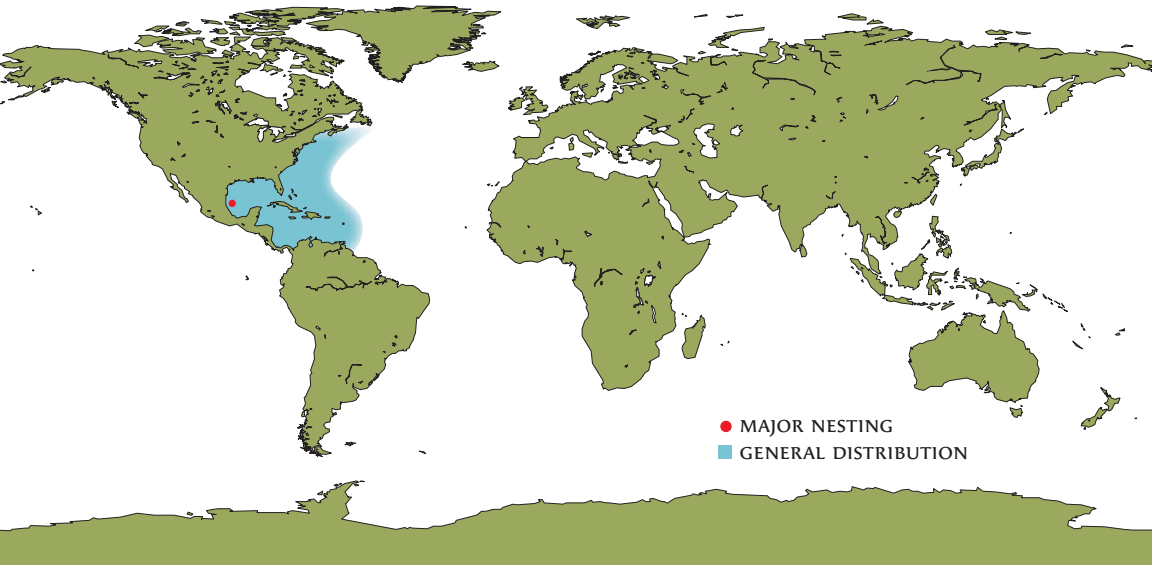
Status

National: Endangered.
International: Critically Endangered.

Kemp's ridley is the most endangered of all the sea turtle species. A few thousand adult females nest in a single locality in Tamaulipas, Mexico, and a very few nest in other scattered locations, such as Padre Island, Texas. Juveniles are frequently encountered along the Gulf and East coasts, but observations of adults outside the Gulf of Mexico are relatively rare. Old films and interviews with witnesses indicate that in 1947 up to forty thousand females nested on the 60-km-long beach at Tamaulipas in a single day. By 1968, the largest single nesting group during a season had declined to an estimated five thousand individuals, and by 1978–1991, no more than two hundred females emerged to nest at one time. Since then the numbers have risen, but they do not approach the numbers seen in the late 1940s. The precipitous decline is attributed to many factors, including harvesting of eggs for human consumption, use of turtles for meat and leather, and death in nets. Conservation efforts have held off extinction, but the number of carcasses washing ashore continues to climb.

Distribution and Habitats

Distribution is restricted to the Gulf of Mexico and the North Atlantic Ocean. Adults apparently occur mostly in the Gulf of Mexico, but juveniles are found seasonally from Massachusetts southward along the U.S. coast. Some juveniles may be caught up in the Gulf Stream and end up near European shores. Kemp's ridleys may travel around the ocean gyre as loggerheads do, but they return to Mexico to nest.



Kemp's Ridley (*Lepidochelys kempii*)

Hatchlings swim near the surface and presumably find refuge in floating debris that collects in drift lines and convergence zones, but juveniles may spend less time in the open ocean than young of the larger sea turtle species do. They return to coastal areas at a carapace length of 20–25 centimeters (8–10 inches). Ridleys spend also less time at the surface than other sea turtles, apparently darting up for a breath of air and then rapidly submerging. Juveniles tracked in the Gulf of Mexico stayed close to shore for relatively long periods. They apparently spend considerable time in shallow estuaries and tidal creeks, as some have been captured in waters behind barrier islands. The migration pattern of juveniles is not clear. Individuals may migrate north along the East Coast every summer until they mature, or that migration may be elective. Occasionally, animals are surprised by the onset of cold weather in the northern latitudes; although they may bury themselves in the mud, they may succumb to freezing temperatures.

Appearance

Size

Kemp's ridleys mature at a smaller size than other sea turtles and reach an average carapace length of about 65 centimeters (25.6 inches). They may weigh up to 45 kilograms (100 pounds) as adults. Juveniles ranging from 22.8 to 60 centimeters (9–24 inches), with coloration essentially the same as adults, have been reported in Georgia waters, and one adult-sized individual was reported from South Carolina. Size at maturity varies, however, and some immature turtles may be within the adult size range. The relatively small size of adults may be correlated with a shorter time to sexual maturity compared with other sea turtles—about 10 years.

Color

The carapace and plastron of hatchlings are dark, but the plastron becomes lighter with age. The carapace of the juvenile and adult is greenish gray, and the skin of limbs, neck, and tail is the same color on the upper surfaces. The lower surfaces are much lighter, usually creamy white. There is no hint of reddish brown color that might cause confusion with loggerheads.

Shell

The general shape is more rounded than that of other sea turtles, especially in large juveniles and adults. The shell is generally about as wide as it is long if measured along the curvature of the carapace. Hatchlings have three prominent keels on the vertebral and costal scutes of the carapace that disappear with age. The keels on the costal scutes disappear at carapace lengths over 25 centimeters, while reduced vertebral (central) keels persist through the 40-centimeter size range.

The nuchal scute abuts the first vertebral scute and the first left and right costal scutes. Anomalous carapace scute arrangements are rather common in ridleys. Fifty percent of the Kemp's ridleys that have stranded on Cumberland Island, Georgia, that were not too decomposed to have scutes (50 animals) had 5 vertebral scutes, 5 pairs of costal scutes, and 13 pairs of marginal scutes on the carapace. The next most common scute pattern (12 percent) was the increase of 1 left marginal scute, bringing the count to 14L/13R. Only 2 percent of the turtles inspected had a reduction in the number of marginal scutes to a 12/12 pattern, and the number of costal scutes was fairly stable. Little epibiota is usually present on ridleys.

TOP

Kemp's ridley is the most endangered of all the sea turtle species. Courtesy of Erin E. Seney.

BOTTOM

Ridleys have two pairs of prefrontal scales on the snout and usually a single row of elongated inframandibular scales along the lower jaw. The upper rhamphotheca is slightly hooked at the tip. Courtesy of Peter C. H. Pritchard.

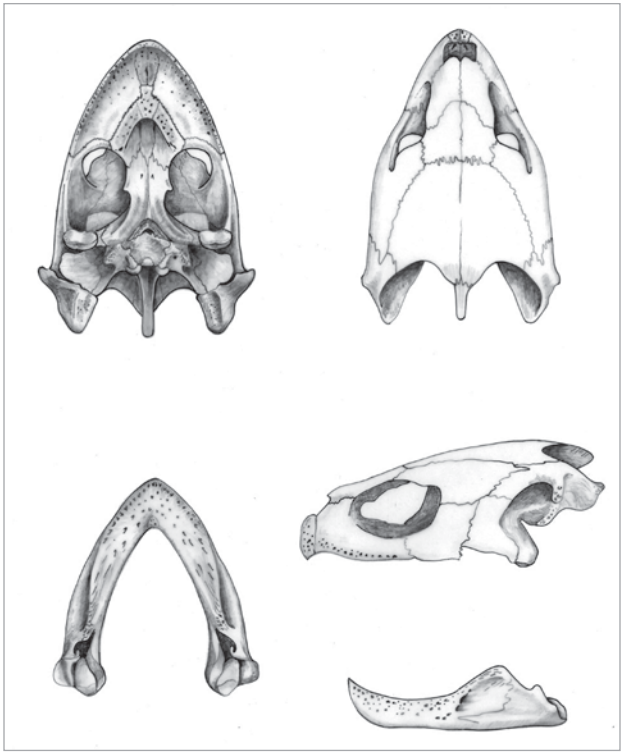


Figure 7. Skull of a Kemp's ridley sea turtle.

The plastron of older juveniles has two low, almost parallel ridges running front to back, formed by the underlying bones; hatchlings have four. Four inframarginal scutes are usually present, each bearing a single pore near the rear seam.

Head

Ridleys have two pairs of prefrontal scales on the snout, and usually a single row of elongated inframandibular scales along the lower jaw. The upper rhamphotheca is slightly hooked at the tip. The skull has several diagnostic features (see Fig. 7, above, and Fig. 27, p. 121).

Limbs

There are two claws on each flipper, as in loggerheads and hawksbills, but the most distal claw is sometimes barely visible. The most prominent claw is strongly curved even in juveniles.

Life History and Behavior

Special Adaptations and Traits

Kemp's ridleys are relatively small, agile, and quick. Their beak is more hooked than that of other species. The geographical limitations on their nesting and general occurrence are unlike those of other sea turtle species in the area.

Diet and Feeding

Ridleys feed mostly on crabs and small mollusks. Crabs, shrimp (probably obtained in shrimp trawl nets), fishes (probably discarded bycatch from shrimp trawlers), moon snails, horseshoe crabs, and occasionally small bivalve mollusks have been found in the digestive tracts of dead animals. Crabs that have been found in intestinal tracts of animals off the Georgia coast, in descending order of frequency, are: spider, purse, calico, speckled, lady, blue, shame-faced, hermit, and stone. Plant material and seeds are sometimes eaten, probably incidentally. The crabs and mollusks eaten are bottom dwellers in near-shore shallow waters or estuaries. Necropsies of ridleys stranded along the European Atlantic shore found no food in the digestive tract.

Growth

Maturity may be reached after 6 years, although one author suggested the age at maturity could be 11 or 12 years. There are few long-term studies on growth.

Nesting

Nesting occurs April–July. Several aspects of nesting are unique. It usually takes place during daylight under special weather conditions, and large numbers of turtles nest more or less simultaneously. Such events are termed *arribadas*. Why such group nesting in daylight should occur has been a matter of considerable speculation. Several advantages seem obvious. *Arribadas* are often associated with strong wind and cloudy conditions that would reduce the likelihood of a turtle overheating while on the beach. The land behind the nesting beach is desertlike. In such habitats most egg and turtle predators are likely to be active at night rather than during the heat of the day. Any predators present in the daytime would be swamped by the enormous number of potential prey and would eat their fill quickly, allow-

An older juvenile. Courtesy of Erin E. Seney.

ing most females to nest unmolested. Olive ridleys also nest simultaneously, but usually at night.

A nesting female Kemp's ridley moves quickly onto the beach and rapidly digs the nest cavity. After her eggs are laid and the nest hole is covered, the female rocks from side to side, lifting her body and packing down the sand, and then moves quickly back to the water.

Eggs, Incubation, and Hatchlings

Females lay up to three or more clutches of eggs in a nesting season, and may nest every year, although they sometimes skip a year or two if food is scarce and they are unable to store the energy required to produce eggs. Recorded intervals between nestings within a season average 3–4 weeks, much longer than for other sea turtles. Apparently eggs are held in the oviducts until conditions favor group nesting. The mean clutch size for these relatively small sea turtles is 100.8 eggs. The eggs average 39 millimeters (1.5 inches) in diameter, about the same size as those of other cheloniids' eggs, so adult turtle size may not be the critical factor in determining egg size.

Incubation time to emergence at the surface ranges from 45 to 58 days,

A New Nesting Beach for Kemp's Ridleys

Biologists hoping to establish new nesting sites for Kemp's ridleys are attempting to imprint hatchlings to the beach at Padre Island, Texas, especially on Padre Island National Seashore. Eggs from the main nesting beach in Mexico were placed in sand from Padre Island and allowed to hatch in captivity, and the turtles subsequently released at various ages on Padre Island in hopes that they would return to nest on U.S. shores. In 2003, thirty-eight nests were documented in Texas, and individuals from the imprinting program have nested on Padre Island. Dispersing the nesting sites of the species is a positive step toward increasing its chances for long-term survival.

and the hatchlings range in length from 38 to 46 millimeters (1.5–1.8 inches). Unlike other sea turtle hatchlings, which generally emerge at night, Kemp's ridleys emerge in the early morning. Based on stranding data from Georgia, the sex ratio for juveniles is roughly two females for every male.

Parasites, Disease, and Predators

Topping the list of native terrestrial predators is the coyote, which patrols the beach around nesting and hatching times. Others include ghost crabs, black vultures, and, of course, fishes once the hatchlings are in the sea. Predators sometimes congregate prior to an *arribada*, indicating their ability to interpret environmental cues.

Few barnacles are found on Kemp's ridleys, and little is known about their internal parasites.

Conservation

Humans caused dramatic declines in the Kemp's ridley population through exploitation of eggs, but that practice is now illegal. The main nesting beaches are now protected, and the number of nesting females is increasing as a result. The primary human impact today is capture and mortality in shrimp trawl nets in the Gulf and along the U.S. East Coast. Strandings since 1980 continue to climb, either because conservation efforts at the nesting beach have increased the population or because increased fishing is killing more turtles (or both). The killing of a single turtle is a serious crime

(punishable by fines up to $25,000 and up to 5 years in prison), but more important, each death is a serious setback in the attempt to save the species from extinction. During the 4-year period 1998–2001, 2,322 Kemp's ridley carcasses were documented along the East and Gulf coasts of the United States. A conservative estimate of actual mortality during that time would be 9,000 animals.

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Olive Ridley

Lepidochelys olivacea

Cheloniidae

Status

National: Threatened.
International: Endangered.

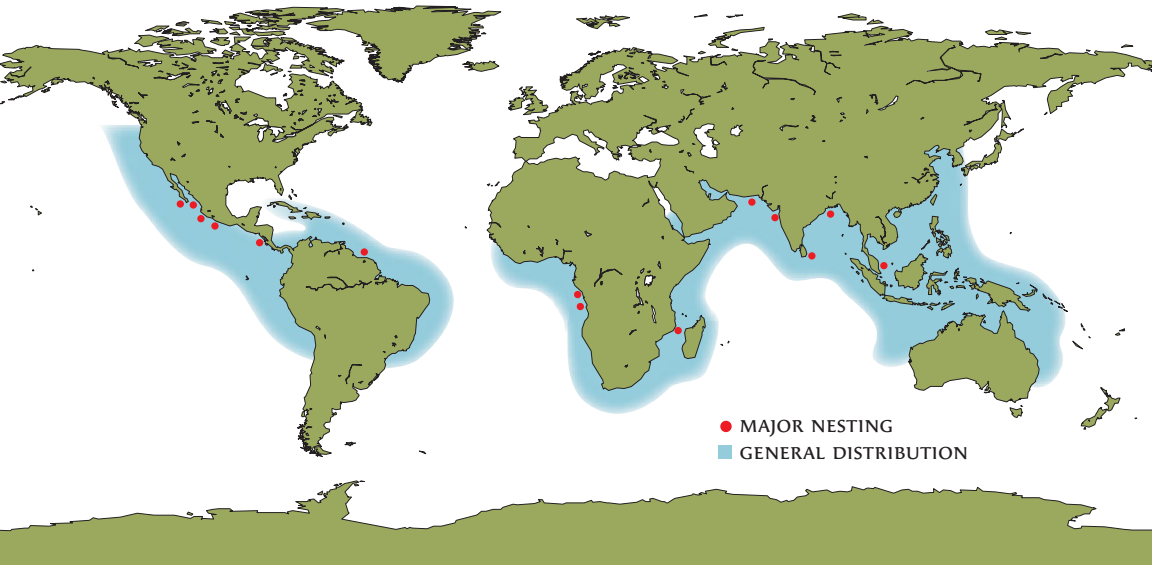
The olive ridley is a tropical species found in the Pacific, Indian, and Atlantic oceans. Major nesting areas occur near low-salinity waters around the mouths of rivers and estuaries. In the western North Atlantic Ocean, the species had been limited to the northern coast of South America, with a few individuals reported from Puerto Rico, the Dominican Republic, and Cuba, until 2003, when the first records of olive ridleys in Florida were documented. This species is the most common nester on the Pacific coasts of Mexico and Central America, and it is thought to be the most numerous of the sea turtles, but numbers are declining in most parts of its range.

Although the possibility of encountering an olive ridley in the region addressed by this book is extremely small, a brief description of its general appearance is provided. The species could become more abundant in the future if range shifts or extensions are occurring and the Florida records do not merely reflect the accidental drifting of injured or sick animals.

Appearance

Size

This is a small, if not the smallest, sea turtle. The adult's carapace length is roughly between 55 and 75 centimeters (22–30 inches), and the weight is up to 45 kilograms (100 pounds).



Olive Ridley (*Lepidochelys olivacea*)

An olive ridley nesting in Trinidad. Courtesy of Suzanne Livingstone.

An olive ridley swimming near Ostional, Costa Rica. Courtesy of Michael Jensen.

A nesting arribada in Ostional, Costa Rica. Courtesy of Michael Jensen.

An olive ridley nesting in Ostional, Costa Rica.
Courtesy of Michael Jensen.

Olive ridley hatchlings are uniformly dark gray above and below.
Courtesy of Muhamad Salamuddin Yusuf.

Color

Hatchlings are uniformly dark gray above and below. Within a couple of months the plastron turns whitish, but the carapace remains gray. Adult color ranges from very dark brown to bright yellowish, but most are dull olive green. The plastron is yellowish.

Shell

The carapace is relatively high and usually less round than that of Kemp's ridleys. It is usually longer than wide and has an irregular number of costal scutes, usually more than 5 per side, which may vary geographically. Scute numbers on each side also tend to be asymmetrical.

Head

There are two pairs of prefrontal scales on the relatively small head.

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Green Turtle

Chelonia mydas

Cheloniidae

Status

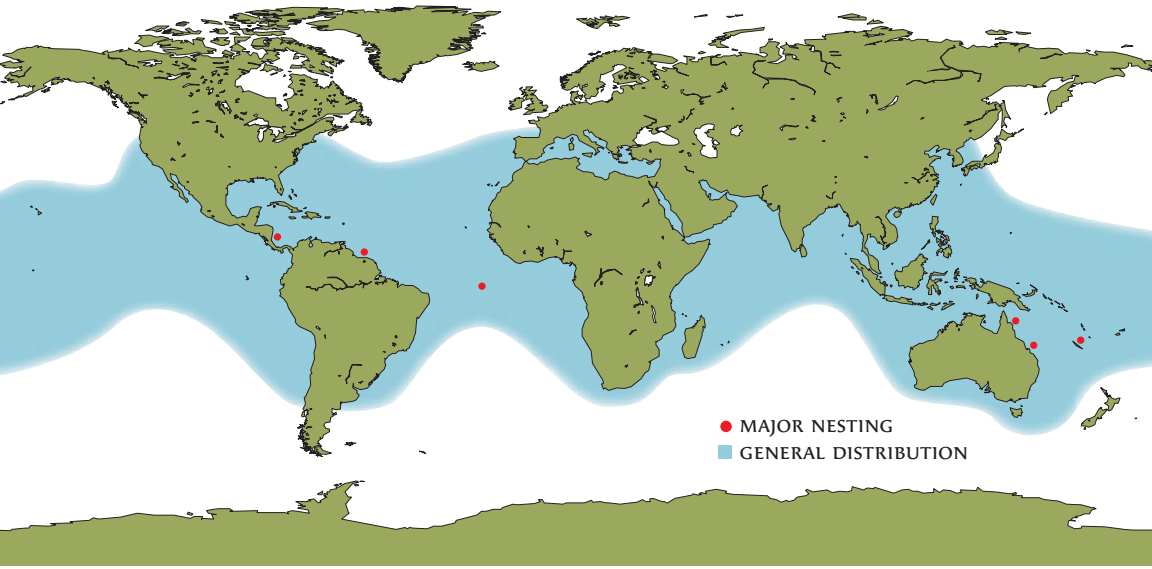
National: Endangered.
Florida nesting population: Threatened.
International: Endangered.

The worldwide abundance of green turtles is unknown, but populations are declining in all ocean basins. Several nesting populations have been lost altogether, and there is no indication that the beaches are being recolonized. Nesting numbers and the number of juveniles in inshore waters indicate that the Florida nesting population is stable or increasing, however, with hundreds to thousands nesting annually.

Distribution and Habitats

Green turtles, mainly a warm-water species, are found in all oceans and have major nesting areas throughout the world. The greatest numbers occur in association with specific foraging and nesting areas such as northeastern Costa Rica, the eastern coast of Surinam, New Caledonia, Ascension Island, and Queensland, Australia. In U.S. waters, green turtles range around the Gulf of Mexico and up the East Coast to New England.

Hatchlings leave the coastal zone for open water and do not return to take up residence in coastal feeding areas until they reach carapace lengths of about 20–35 centimeters (8–14 inches). They utilize estuarine and near-shore or marsh habitats where sea grasses and algae are available. Popular areas include shallow waters along the Texas coast and along the Florida east and west coasts, especially bays, lagoons, and the Keys. A few Florida females tracked by satellite moved south after nesting and followed the



Green Turtle (*Chelonia mydas*)

Keys west to extensive marine grass flats to feed. Large juveniles and adults seasonally migrate to and from coastal foraging areas, including along the northeastern Atlantic coast. Adults make fairly direct, sometimes very long-distance migrations to breeding areas.

Appearance

Size

Adult green turtles in U.S. waters are smaller than those in some other populations, but they are still the largest of the cheloniid sea turtles present, reaching carapace lengths of 122 centimeters (48 inches) and weights of more than 160 kilograms (350 pounds). Adults nesting on Ascension Island in the South Atlantic are much larger (about 660 pounds).

Color

Green turtles are not green. They vary greatly in coloration, but Gulf and North Atlantic specimens are dark brownish with light and dark streaks radiating out from a point at the posterior margin of each scute on the carapace. The lower surface of the plastron and appendages is light yellow

Like other large marine animals, sea turtles sometimes carry remoras (small fish specialized to attach themselves to moving objects). Courtesy of Caroline Rogers.

to whitish. The plastron of hatchlings and very young turtles is white, as are the margins of the flippers and shell. The name "green turtle" refers to the color of the fat.

Shell

Green turtles can be distinguished from almost all loggerheads and ridleys by their four pairs of costal scutes. Both the nuchal and first marginal scutes are in contact with the first vertebral scute. Other scute differences are not always definitive. The openings between most pleural and peripheral bones of the carapace do not disappear with age. Green turtles usually have few barnacles or other epibiota.

Head

The head is relatively small with well-defined, dark scales and a single pair of prefrontal scales. Green turtles differ from all other sea turtles in having serrations (jagged edges) on the lower beak (Fig. 8) that help them harvest the grass on which they feed. The upper beak is bluntly rounded at the front of the snout and has strong vertical ridges on the inner surface. The skull is high-domed or boxy when viewed from the side (Fig. 9).

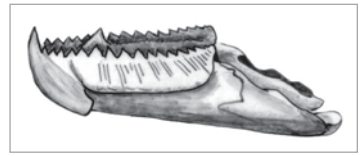


Figure 8. The serrated jaw of a green turtle.

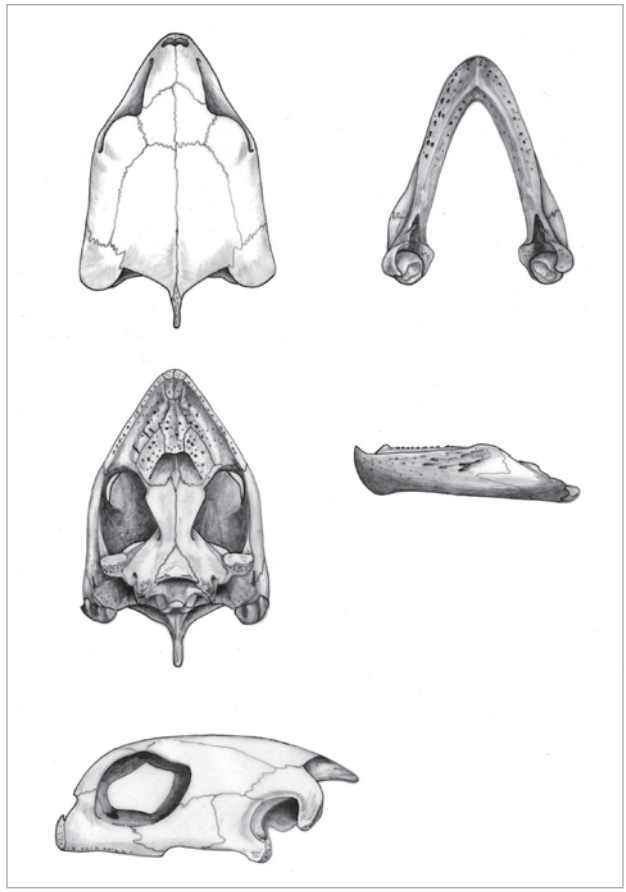


Figure 9. Skull of a juvenile green sea turtle.

Limbs

Green turtles have a single claw on each flipper. A second claw may be present in the young only. The tips of the front flippers have sharp, hardened edges that are used to scrape off commensal organisms such as barnacles that are trying to settle on the shell. Once barnacles are securely attached, however, the turtle cannot scrape them off.

Life History and Behavior

Special Adaptations and Traits

Adult green turtles frequently travel long distances between feeding and nesting areas. The grasses on which they feed grow only in shallow areas, yet they frequently nest in areas where sea grass does not grow. For example, one population nests on Ascension Island, in the middle of the South Atlantic Ocean, and its feeding grounds are along the coast of Brazil, about 2,250 kilometers (1,400 miles) away.

Young green turtles living in the open ocean feed on small animals such as invertebrates. When older juveniles leave the open-ocean environment to reside in coastal waters, they switch from a carnivorous to an herbivorous diet and at that time undergo modifications to their digestive system. The large intestine becomes greatly enlarged (doubled in length) to properly process plant material.

The green turtle is one of the few sea turtle species that basks on land (observed in Hawaii and Australia). All sizes and sexes participate in this behavior.

Diet and Feeding

Marine grasses and algae are the primary diet of adults and young green turtles in near-shore environments. The snails and other small organisms that live on the plants also contribute to nutrition. Many species of grasses and algae are consumed, and in prodigious quantities. Even small green turtles sometimes have 1–2 liters (0.25–0.50 gallon) of plant material packed in their intestinal tract. Some juveniles that strand on beaches in Georgia have coarse marsh grass and algae in their intestinal tracts, as do stranded manatees. Whether manatees and green turtles compete for food is unknown, but in that area, access to feeding areas is restricted by low water.

Two juvenile green sea turtles. Courtesy of Jeff Lovich and Carol Ruckdeschel.

Since marsh grass is available along tidal creeks of the coast only at high tide, feeding must be correlated with tides. Like many terrestrial grazers, individuals may return to specific grazing sites to crop the nutrient-laden, newly sprouted grass, and thus create "pastures." Unlike ruminant mammals, which have four-chambered stomachs to augment breakdown of vegetation by microorganisms, green turtles digest their food in the large intestine (specifically the part of it called the cecum).

Post-hatchlings are carnivorous while in the open ocean. Captives raised from the hatchling stage prefer chopped fish and trout chow to algae and marine grasses, at least until they are over 3 years old.

Green turtles are not green. Gulf and North Atlantic specimens are dark brownish with light and dark streaks radiating out from a point at the posterior margin of each scute on the carapace. Courtesy of Alejandro Fallabrino.

Growth

Age at sexual maturity has been estimated at between 12 (Costa Rica) and 50 years (Hawaii) depending on location and nutritional history. Green turtles fed a high-protein diet in captivity matured in 16 years. Longer times to maturity might be expected for animals in the wild. Information from tagged animals indicates that their reproductive life span is between 22 and 50 years. The few studies of sex ratio reached different conclusions in different locations. There were significantly more females in one area, and about the same number of males and females in another.

Nesting

The nesting season in the southeastern United States is June–September; nesting occurs throughout the year in tropical areas. Green turtles have high nest site fidelity and return on average after a 2-year or 3-year hiatus. Females lay an average of three clutches (up to eight) at roughly 13-day in-

The tips of a green's front flippers have sharp, hardened edges that are used to scrape off commensal organisms such as barnacles that are trying to settle on the shell. Once barnacles are securely attached, however, the turtle cannot scrape them off. Courtesy of Michael Coyne and Seaturtle.org.

The green turtle is one of the few sea turtle species that basks on land. Courtesy of Michele Block.

Green turtles usually prepare a deep body pit before digging a nest chamber. Courtesy of Alan F. Rees / ARCHELON.

tervals. Female green turtles attempting to crawl up on nesting beaches are much more skittish than females of other species and more commonly leave false crawls (aborted nesting crawls). When crawling, the females move both front limbs at the same time, making a track different from that of all other sea turtles except leatherbacks. Hatchlings use the typical alternate limb gait. Green turtles tend to plow a deep track and usually prepare a deep body pit before digging a nest chamber. The hind feet are directed backward over the tail during egg-laying to protect the dropping eggs from any disturbance by predators. After depositing more than a hundred eggs and covering the nest, a female usually makes a direct track back to the sea. One researcher reported 2.5 hours as the average time of a nesting event.

Eggs, Incubation, and Hatchlings

Green turtle eggs range in diameter from about 34 to 59 millimeters (1.3–2.3 inches) and average 45 millimeters (1.8 inches); they hatch in slightly less than 2 months. The carapace of hatchlings is about 50 millimeters (1.9 inches) once it uncurls from the rounded shape it holds inside the egg. Hatchlings presumably swim seaward until they reach floating cover. Meanwhile, their pronounced countershading (light belly, dark top) must protect them from many visually oriented predators whether these approach from above or below.

The margins of the flippers and shell of hatchlings and very young turtles are white.
Courtesy of Kellie Pendoley.

Green turtles can be distinguished by their single pair of prefrontal scutes.
Courtesy of Kara Dwyer Dodge.

Green turtles have serrations on the lower beak. The upper beak is bluntly rounded at the front of the snout and has strong vertical ridges on the inner surface. The skull is high-domed or boxy when viewed from the side. Photo by Carol Ruckdeschel.

Parasites, Disease, and Predators

Fibropapillomatosis affects green turtles and can significantly impair their activity and health. A high prevalence of the disease has been reported in animals from Florida Bay (69 percent infected) and Indian River, Florida (40–60 percent). It has been observed on turtles in the Caribbean and Mexico, but only one diseased individual has been reported from along the East Coast north of Florida. Several species of barnacles occur on green turtles, and in some populations leeches are common parasites. Trematodes and cestodes have been identified as internal parasites.

Conservation

According to one estimate, the present number of green turtles in the Caribbean region is 3–7 percent of the number that existed there before humans began exploiting and killing them. Green turtles are the most numerous large vertebrate herbivores of the oceans; consequently, they are likely to play a major role in the functioning of marine grassland ecosystems. Such systems are the nursery grounds for numerous species and are among the most productive ecosystems of the world. The reduction in numbers of green turtles has no doubt greatly modified the structure and dynamics of marine grasslands. The massive slaughter of green sea turtles and manatees parallels the near extinction of the bison in North America, probably with similar results to the ecosystems of which they were a part.

Green turtles have long been considered a gastronomic delight, and large numbers have been killed for centuries. Green turtle soup, thickened by the

cartilaginous material of the plastron and carapace, is renowned in many countries. In the past, this species provided a ready supply of excellent fresh meat for mariners, as the turtles could be kept alive on their backs in the hold of a ship for months. In fact, the green turtle has been credited with contributing to the success of the Spanish colonization of America. In 1738, William Stephens, later secretary to the Georgia Trust, recorded that "two thousand weight of turtle" (2,240 pounds, no doubt green turtles) were brought to Savannah on a sloop from Providence (Bahamas). By 1878, fifteen thousand green turtles per year were being shipped to England from the Caribbean. Add to that the regular harvesting of eggs, and it is not difficult to understand why this species is so reduced in numbers today.

Trade in green turtles has been decreased greatly through the efforts of many individuals and the governments that signed the 1973 Convention in International Trade in Endangered Species of Wild Fauna and Flora (CITES). At present, the greatest threat to this species in the United States is loss of nesting habitat. Egg harvesting has been slowed through enforcement of the Endangered Species Act and reciprocal action by other countries. Green turtle strandings along the East and Gulf coasts for the 4-year period 1998–2001 were 1,999, with estimated actual mortality at almost 8,000 individuals.

Selected Reference

Hirth, H. F. 1997. *Synopsis of the Biological Data on the Green Turtle,* Chelonia mydas *(Linnaeus 1758).* USFWS Biological Report 97(1). 120 pp.

Hawksbill

Eretmochelys imbricata

Cheloniidae

Status

National: Endangered.
International: Critically Endangered.

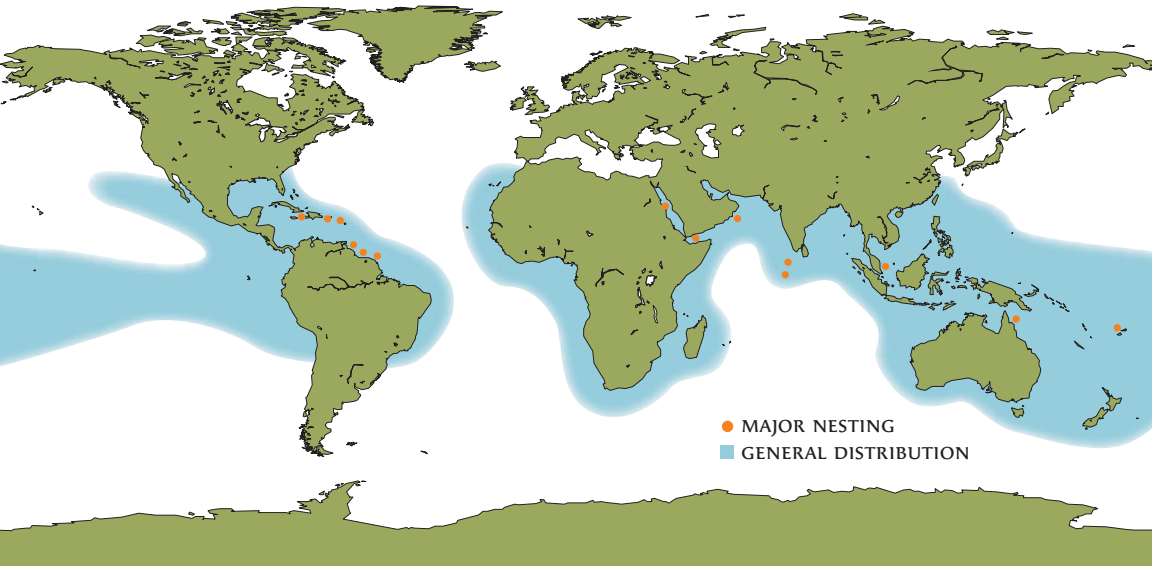
Hawksbills are not abundant in U.S. waters. Most populations are considered to be declining, but relatively large nesting populations still occur in Yemen, northeastern Australia, the Red Sea, and Oman.

Distribution and Habitats

Coral reefs, rocky outcrops and rubble piles, and shallow seas throughout the tropics are typical habitats for this widely distributed species. Major nesting beaches are in northern Australia, the Fiji Islands, East Malaysia, many groups of islands in the Indian Ocean and along the coasts of the Arabian and Red seas, southwest Brazil, Surinam, French Guiana, Guyana, along the Yucatán Peninsula, and islands in the Caribbean.

Specimens have been encountered along the Atlantic coast north to Massachusetts and along the Gulf coast, but are uncommon north of south Florida. Some hawksbill females migrate short distances from specific feeding areas to nesting beaches while others travel hundreds to thousands of kilometers. The migrations seem to be direct routes that may cross deep channels or ocean waters, or may follow shallow coastal waters. Individuals from different natal/nesting beaches share foraging areas, so members of any given foraging group may have followed greatly different migratory routes to the area.

Hatchlings have been reported drifting in floating sargassum in the open



Hawksbill Turtle (*Eretmochelys imbricata*)

sea and are known to spend their early years there, returning to inshore Caribbean habitats at carapace lengths of 20–25 centimeters (8–10 inches). Most U.S. specimens are juveniles.

Appearance

Size

Carapace length may reach 90 centimeters (35 inches), but most adults are smaller than that and weigh less than 100 kilograms (220 pounds). Hatchling size is related to egg size; the range is 38–46 millimeters (1.5–1.8 inch) carapace length.

Color

Hawksbills, especially medium-sized juveniles, are among the most beautiful creatures of the sea. The scutes are the classic tortoiseshell pattern of yellow with dark brown or black markings. The color pattern on each hawksbill is unique, but individuals from the same nesting colony tend to exhibit similar relative amounts of dark and light coloration.

Hatchlings are quite variable in color and may not be as countershaded

Coral reefs and shallow tropical seas are typical habitats for hawksbills. Courtesy of Steve Cohen, OAR/National Undersea Research Program, UNC Wilmington, and Michelle Tanya Scharer.

(dark above and light below) as green turtles are; they more resemble loggerheads. They do not exhibit the typical tortoiseshell pattern but are generally shades of brown with light tan or yellow on the carapace margins, tips of keels on the carapace, and areas of the plastron. Older animals are usually less colorful, often due to abrasive wear to the shell, and tend toward darker shades of brown and greenish yellow.

Shell

Hawksbills have four pairs of costal scutes. Overlapping or imbricate carapace scutes are a characteristic of medium to large juveniles. Most scutes become juxtaposed or adjacent to each other after the small juvenile stage. The shell may appear elongate compared with that of ridleys and loggerheads. The anterior margin of the nuchal scute is about half the length of the posterior margin, and that scute is not in contact with a costal scute. Barnacles and other epibiota are common on hawksbills, although not to the same degree as on loggerheads.

Head

Two pairs of prefrontal scales cover the snout. The front part of the head or snout is beaklike and narrower than that of other sea turtles, but this difference is obvious only in side-by-side comparisons. The entire skull is comparatively narrower than that of other cheloniids, and the tip of the beak angles forward rather than down (Fig. 10, p. 102), thus the common name "hawksbill."

Limbs

There are two claws on each front flipper, as there are on ridleys and loggerheads. Scales on the limbs are dark, ringed by yellow; the claws are whitish or light colored.

Life History and Behavior

Special Adaptations and Traits

As its name implies, the beak is "hawklike" and narrow, a shape that helps the turtle feed in tight crevices in coral and other hard substrates. The ability to exploit sponges, a food resource no other sea turtles eat, eliminates some competition for food. Skeletons of sponges may be composed of indigestible siliceous spicules that are similar to glass needles.

TOP

Sponges are a major component of hawksbills' diet, but large juveniles and adults are known to feed on a variety of sessile invertebrates as well. Courtesy of NOAA, NERR collection.

BOTTOM

The scutes of a hawksbill are the classic tortoiseshell pattern of yellow with dark brown or black markings. Courtesy of Johan Chevalier.

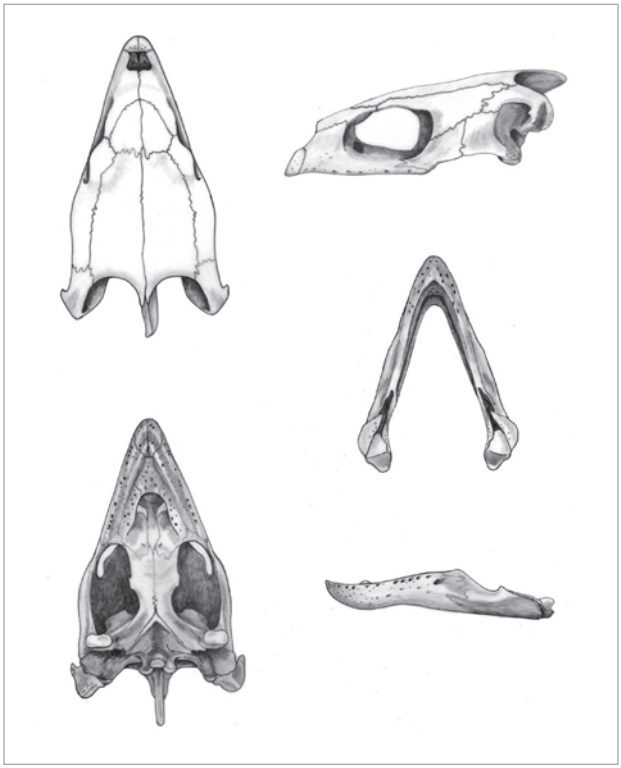


Figure 10. Skull of a hawksbill turtle.

Hawksbills sleep wedged into coral or rock formations. Various authors have described their disposition as docile, touchy, aggressive, and pugnacious.

Diet and Feeding

Sponges are a major component of hawksbills' diet in the Caribbean. Their intestinal tract is often packed with sponge spicules, but both large juveniles and adults are known to feed on a variety of sessile (immobile) invertebrates as well. When feeding on such animals they may accidentally consume non-food items along with food, as do most sea turtles. Hawksbills can eat some poisonous organisms without harm to themselves, but the turtle's flesh then becomes toxic to humans.

Growth

Hawksbills may take 4 years or more to mature; the time varies according to nutritional history and the population to which the turtle belongs. As is

Hawksbill hatchlings do not exhibit the typical tortoiseshell pattern but are generally shades of brown with light tan or yellow on the carapace margins, tips of keels on the carapace, and areas of the plastron. Courtesy of Dr. Renata Platenberg.

The front part of the hawksbill's head is beaklike and narrow. The tip of the beak angles forward rather than down. Courtesy of Steve Cohen.

Hawksbill nests are often constructed in vegetation. Photo by Meg Hoyle.

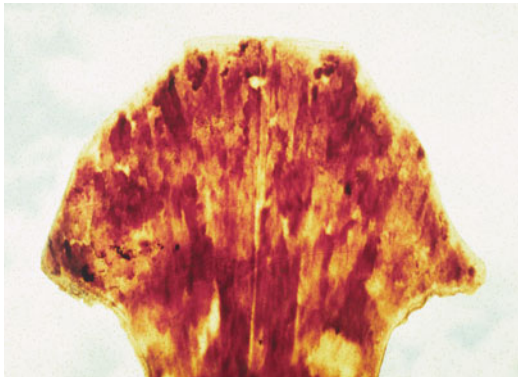
the case for all sea turtles, the temperature during incubation determines the sex of the developing embryo, and both male-biased and female-biased groups have been reported in the Caribbean.

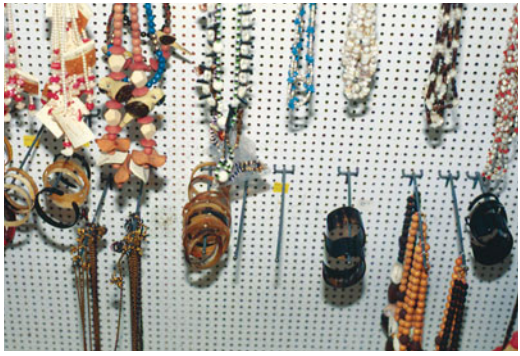
Nesting

Mating takes place near nesting beaches. Nesting is mainly a summer through late autumn event in the Caribbean and south Florida, although nesting has been recorded during most months of the year and varies with geographic location. There is no nesting along the Gulf coast. Hawksbills nest two to four times or more a season at 2–3-week intervals, and may return on a 2–3-year cycle. Nesting site fidelity is high. Compared with other sea turtles, hawksbills are agile in their nesting excursions, making rapid progress with alternate movements of the limbs (diagonal limbs moving simultaneously) as they travel to a suitable nesting site. Nests are often constructed in vegetation, but the nest itself resembles those of other cheloniids.

Eggs, Incubation, and Hatchlings

Eggs from clutches laid in the Virgin Islands measure 39–40 millimeters (1.5–1.6 inches) in diameter (smaller in the western Pacific) and may number up to more than 200, although the average is less than 160. Because it depends on the temperature, the incubation period—from egg-laying to





TOP
Hawksbills have been persecuted for their scutes—the "tortoiseshell" used in the manufacture of combs, eyeglass frames, and furniture. Photo by Meg Hoyle.

MIDDLE
Plastics offer an alternative to items made from hawksbill scutes. Photo by Meg Hoyle.

BOTTOM
Hawksbills are also hunted for their meat and eggs. Photo by Meg Hoyle.

time of emergence—varies from 41 to 91 days, but it is usually about 60 days. After hatching, several days may be required for the hatchlings to reach the surface, and then emergence may take place during the following 4–6 nights. At that time the carapace length is about 42 millimeters (1.7 inches).

Parasites, Disease, and Predators

Hawksbills have both internal and external parasites, but very little is known about the prevalence of disease. Like other sea turtles, they have a variety of natural predators including sharks, killer whales, groupers, and even crocodiles.

Conservation

Hawksbills have been severely persecuted for many years for their scutes—the "tortoiseshell" used in the manufacture of combs, eyeglass frames, and furniture, especially prior to the introduction of plastics. Demand still exists for this expensive material, and there has been talk of developing hawksbill ranches in Cuba. They are also hunted for their meat and eggs. More recently, destruction of coral reefs and nesting beaches has had serious impacts on hawksbill nesting success. In addition, snorkel and scuba gear allows increased human access to hawksbill habitats, and divers hunting for other species such as spiny lobsters find and take hawksbills as well. Juveniles are popular as stuffed animals in the foreign tourist trade, but it is illegal to bring them into the United States.

Conservation efforts have been directed at stopping the international tortoiseshell and stuffed sea turtle trade in addition to protecting live animals, but only the populations in Malaysia seem to be showing a positive response. Hawksbills are also vulnerable to commercial fishing activities. During the period 1998–2001, 186 hawksbill strandings were reported along the Atlantic and Gulf coasts, suggesting actual mortality to be about 700 individuals.

Selected Reference

Witzell, W. N. 1983. *Synopsis of Biological Data on the Hawksbill Turtle,* Eretmochelys imbricata *(Linneaus, 1766).* FAO Fisheries Synopsis No. 137. 78 pp.

Epilogue

All sea turtle species have declined during the past 200–300 years as a direct or indirect result of human activities. All species are officially recognized as in need of assistance to relieve the pressures limiting their reproductive success and survival to maturity. Our challenge is to develop and implement successful management plans to counteract the myriad threats the turtles face. Such plans affect numerous human activities worldwide and require a multinational effort that has been gaining momentum in recent years as more and more people have become aware of the plight of sea turtles. The United States has been a leader of the nations advocating sea turtle conservation, but effective conservation of animals with international ranges requires international collaboration. Much more will have to be done if we are to reverse the declining trend for most populations. The greater the public interest, the more effort the government will put into an issue, so public awareness is very important to sea turtle protection. If conservation measures are to work, people must understand why nesting beaches must be protected; why beachfront lighting and many beach stabilization methods are problems for sea turtles; and that commercial trawl nets, gill nets, longlines, and lobster pot lines can be and are lethal to sea turtles.

It *is* possible to reverse the downward spiral of many sea turtle populations, as the conservation efforts for Kemp's ridleys have shown, but much still needs to be done. At the very least the turtles must have protected beaches for nesting and the freedom to migrate and feed without encountering deadly commercial fishing gear. As the human population continues to increase, so will the pressure exerted on most species.

Except for a few particularly charismatic animals, marine species are not as obvious to us as terrestrial ones, so they usually receive less attention. But ultimately all contemporary species are partners on the planet, and the fate of one impacts all the others. The late Archie Carr, dean of sea turtle biologists, commenting on the loss of species, said it best: "And we shall head into the rest of our time, masters of creation at last, and alone forever."

How to Help Sea Turtle Conservation Efforts

Individuals can aid sea turtle conservation efforts in many ways. The route chosen depends on the amount of time and money the person wants to invest. Many countries have national conservation societies that take a direct interest in sea turtles.

1. Become informed about the issues.
2. Write to government representatives—state and federal—asking them to support conservation efforts.
3. Support national conservation organizations and the sea turtle programs they sponsor.
4. Individuals who live in coastal areas should inquire locally. Many projects are in need of helpers, and personal involvement with sea turtles is an enormously rewarding experience available to very few.

Commercial trawl nets can be lethal to sea turtles.
Photo by Carol Ruckdeschel.

Appendix

Keys to Sea Turtles of the U.S. Atlantic and Gulf Coasts

Note: Sketches are based primarily on juvenile specimens.

Key to Living Animal or Fairly Fresh Carcass, Intact Animal

A Carapace black or grayish black, sometimes with light flecks of bluish white or pink; longitudinally ridged; smooth skin covers and hides the mosaic of small bones that form the carapace. . . . . *Dermochelys coriacea,* leatherback, p. 35

A Carapace not black, without longitudinal ridges; horny scutes cover large bones that form the carapace . . . . . B

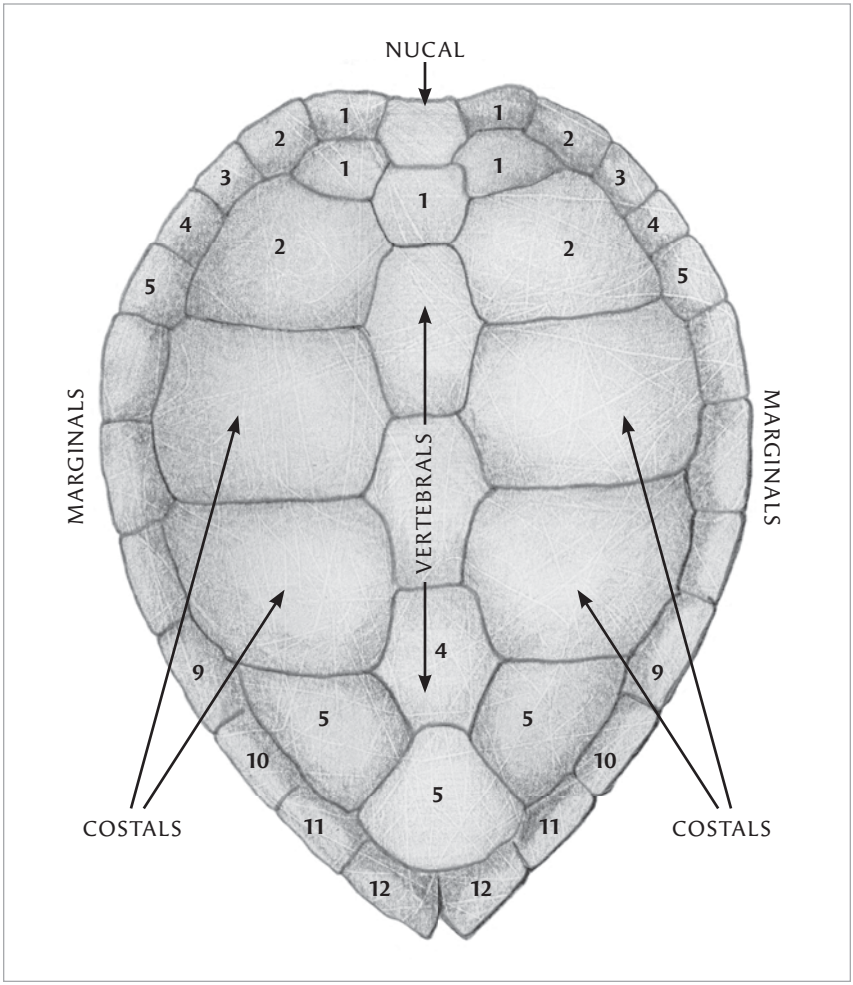


Figure 11. Names of scutes.

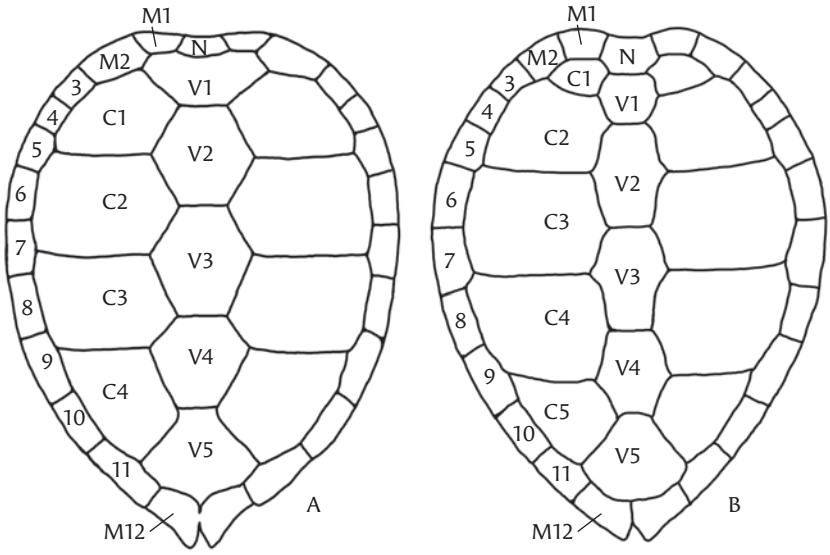


Figure 12. Scute arrangements.

B Costal scutes 4; nuchal scute and first marginal scute in contact with first vertebral scute (Fig. 12A) C
B Costal scutes 5; nuchal scute but no marginal scutes in contact with first vertebral scute (Fig. 12B) . . . . . D

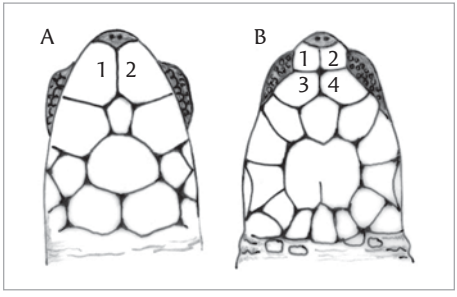


Figure 13. Scale arrangements on the head.

C Two large scales between eyes (Fig. 13A) . . . . . *Chelonia mydas,* green turtle, p. 85
C Four scales between eyes (Fig. 13B) . . . . . *Eretmochelys imbricata,* hawksbill, p. 97

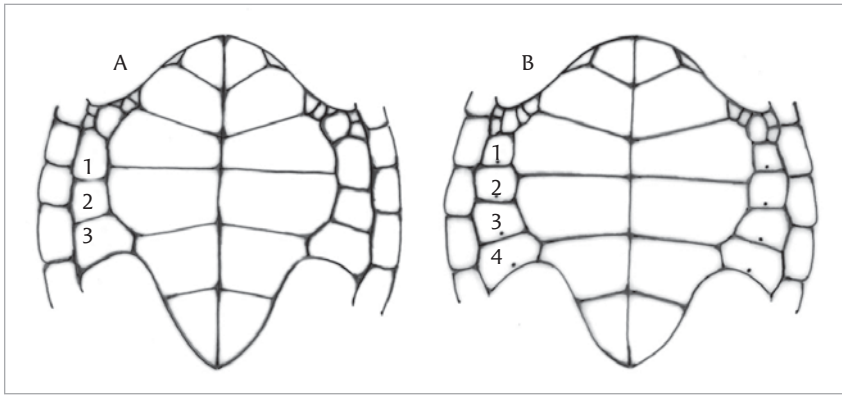


Figure 14. Inframarginal scales.

D Inframarginal scales usually 3 (Fig. 14A), with no pores; carapace reddish brown ..... *Caretta caretta,* loggerhead, p. 53

D Inframarginal scales usually 4, each with a pore near the posterior seam (Fig. 14B) ..... E

E Carapace gray; costal scutes usually 5 pairs. .... *Lepidochelys kempii,* Kemp's ridley, p. 69

E Carapace olive green; costal scutes usually 6 – 9 pairs, asymmetry frequent ..... *Lepidochelys olivacea,* olive ridley, p. 79

Key to a Fairly Fresh Carcass, Head Missing

A Carapace black; longitudinally ridged; smooth skin covers the mosaic of small bones that form the carapace ....*Dermochelys coriacea,* leatherback, p. 35

A Carapace not black; without longitudinal ridges; scutes cover the large bones that form the carapace ..... B

B Costal scutes 4; nuchal scute not in contact with first costal scute (Fig. 12A) C

B Costal scutes 5; nuchal scute in contact with first costal scute (Fig. 12B) ..... D

C One claw on each front flipper (Fig. 15A) .... *Chelonia mydas,* green turtle, p. 85

C Two claws on each front flipper (Fig. 15B). ....*Eretmochelys imbricata,* hawksbill, p. 97

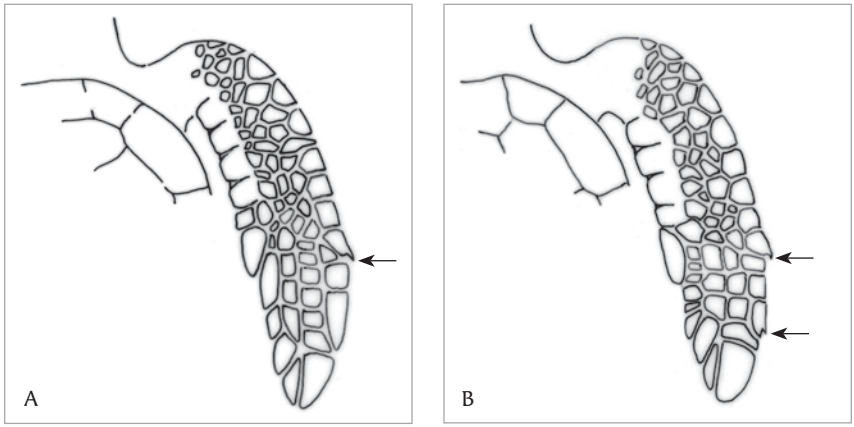


Figure 15. Flippers, showing claws.

D Inframarginal scales usually 3, with no pores; carapace reddish brown (Fig. 14A) . . . . . *Caretta caretta,* loggerhead, p. 53

D Inframarginal scales 4 (Fig. 14B), each with a pore near the posterior seam . . . . . E

E Carapace gray; costal scutes usually 5 pairs. . . . . *Lepidochelys kempii,* Kemp's ridley, p. 69

E Carapace olive green; costal scutes usually more than 5 pairs, asymmetry frequent in numbers . . . *Lepidochelys olivacea,* olive ridley, p. 79

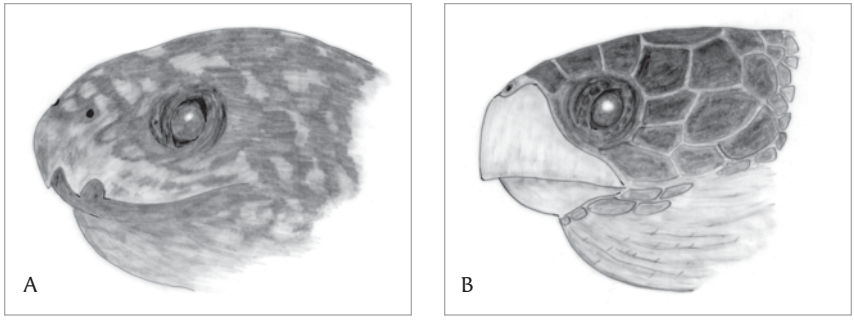


Figure 16. Heads, showing upper jaws.

Key to Fairly Fresh Head Only

A Upper jaw deeply notched on each side (Fig. 16A). . . . . *Dermochelys coriacea,* leatherback, p. 35

A Upper jaw not deeply notched (Fig. 16B). . . . . B

B Two large scales between eyes (Fig. 13A); cutting edge of lower rhamphotheca serrated (Fig. 17A) . . . . . *Chelonia mydas,* green turtle, p. 85

B More than 2 scales between the eyes (Fig. 13B); cutting edge of lower rhamphotheca not serrated (Fig. 17B) C

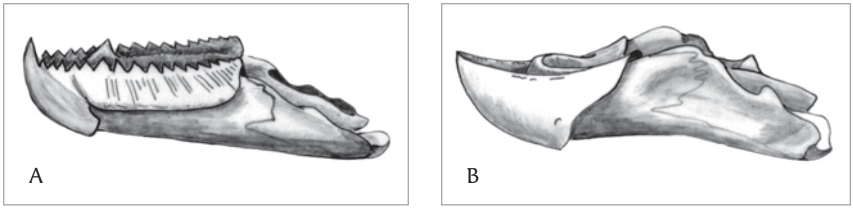


Figure 17. Lower rhamphothecas.

C Anterior tip of upper rhamphotheca more or less straight, without a hook; head long and narrow (Fig. 18A) . . . . . .*Eretmochelys imbricata,* hawksbill, p. 97

C Anterior tip of upper rhamphotheca curved downward; head broad (Fig. 18B). . . . . D

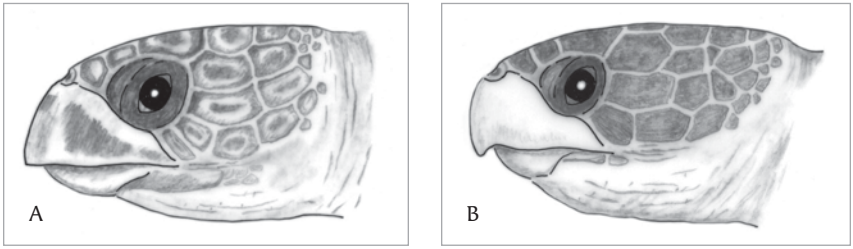


Figure 18. Upper rhamphothecas.

D Anterior tip of upper rhamphotheca distinctly hooked (Fig. 19A); single row of inframandibular scales; from ventral aspect, center of posterior edge of lower rhamphotheca usually gently curves anteriorly (Fig. 20A) . . . . . *Lepidochelys kempii,* Kemp's ridley, p. 69

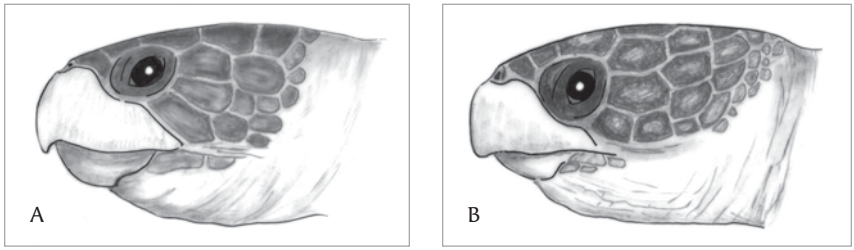


Figure 19. Heads, showing beak variations.

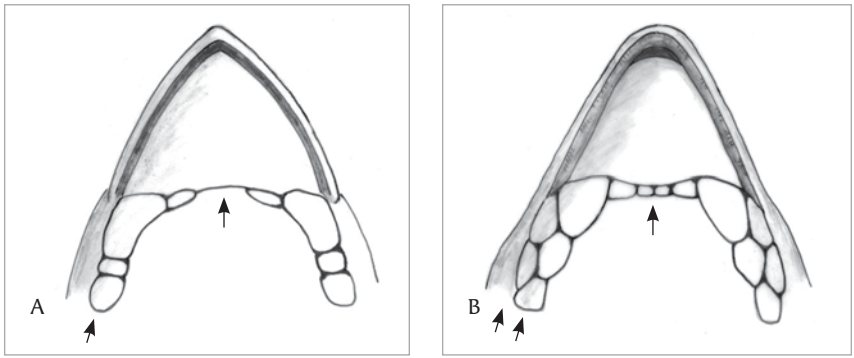


Figure 20. Lower jaw sheaths.

D Gentle curve near tip of upper tomium (Fig. 19B); double row of inframandibular scales; from ventral aspect, center of posterior edge of lower tomium usually gently curves posteriorly (Fig. 20B) . . . . . *Caretta caretta,* loggerhead, p. 53

Key to Fairly Fresh Carcass, Head and All Limbs Missing

A Carapace black, longitudinally ridged; smooth skin covers the mosaic of small bones that form the carapace . . . . . *Dermochelys coriacea,* leatherback, p. 35

A Carapace not black, without longitudinal ridges; horny scutes cover the large bones that form the carapace . . . . . B

B Costal scutes 4; nuchal scute not in contact with first costal scute (Fig. 12A) C

B Costal scutes 5; nuchal scute in contact with first costal scutes (Fig. 12B) . . . . . D

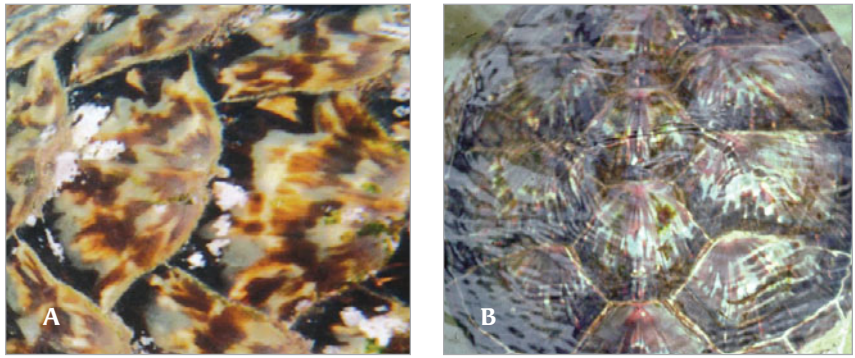


Figure 21. Scute patterns.

C Scutes overlapping (except in very young or very old specimens); tortoiseshell pattern on scutes (Fig. 21A) . . . . . .*Eretmochelys imbricata,* hawksbill, p. 97

C Scutes not overlapping; scutes without tortoiseshell pattern (Fig. 21B) . . . . . *Chelonia mydas,* green turtle, p. 85

D Inframarginal scales usually 3, with no pores (Fig. 14A); carapace reddish brown . . . . . *Caretta caretta,* loggerhead, p. 53

D Inframarginal scales usually 4, each with a pore near the posterior seam (Fig. 14B) . . . . . E

E Carapace gray; costal scutes usually 5 pairs . . . . *Lepidochelys kempii,* . . . . . .Kemp's ridley, p. 69

E Carapace olive green; costal scutes usually 6 – 9 pairs . . . . . *Lepidochelys olivacea,* olive ridley, p. 79

Key to Plastral Bones Only

A Plastral bones thin, forming a ring (Fig. 23A); no entoplastron . . . . . *Dermochelys coriacea,* leatherback, p. 35

A Plastral bones not forming a ring (Fig. 23B); entoplastron present . . . B

B Length of entoplastron less than 6 times the width at midpoint; ratio of width (at widest point) to length of epiplastron less than 0.24 (Fig. 24) C

B Length of entoplastron greater than or equal to 7 times the width at midpoint; ratio of width (at widest point) to length of epiplastron greater than 0.24 (Fig. 24) . . . . . D

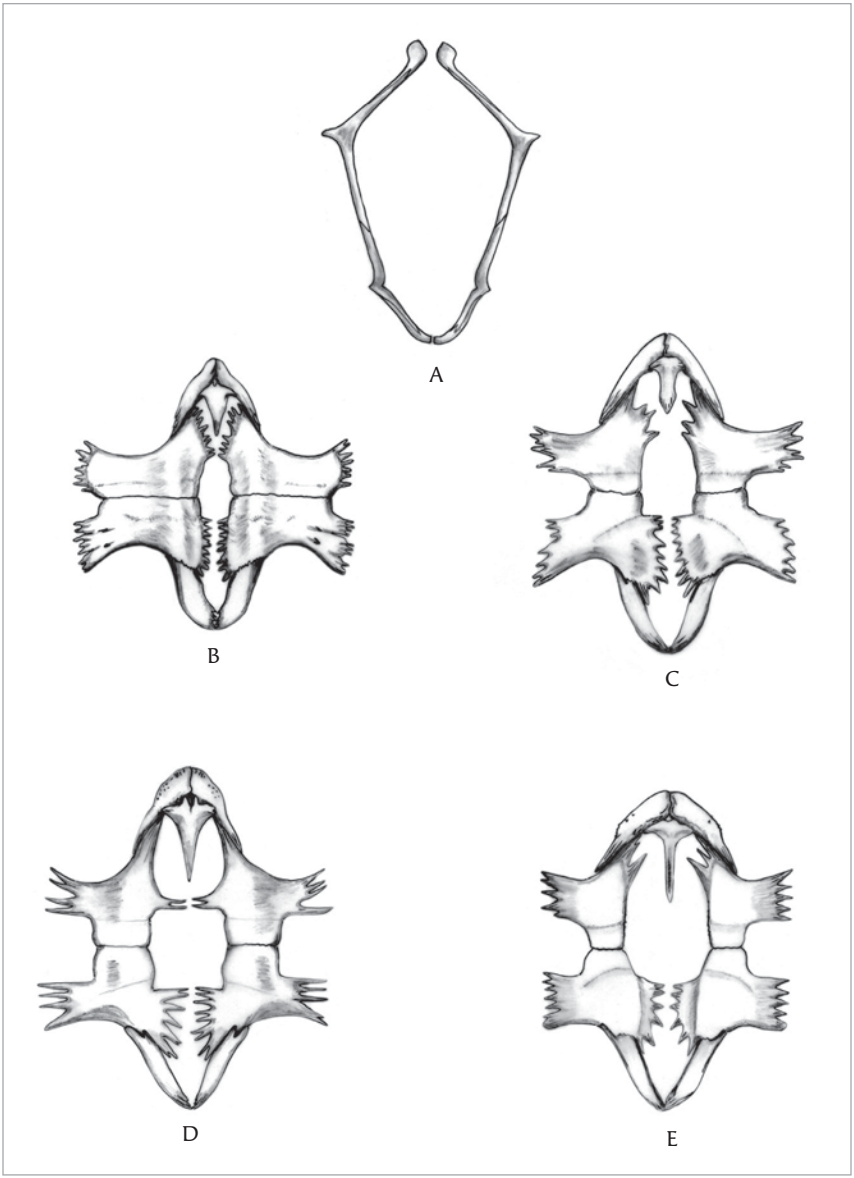


Figure 22. The supportive bones of the plastron of sea turtles: (A) leatherback, (B) Kemp's ridley, (C) loggerhead, (D) green, (E) hawksbill.

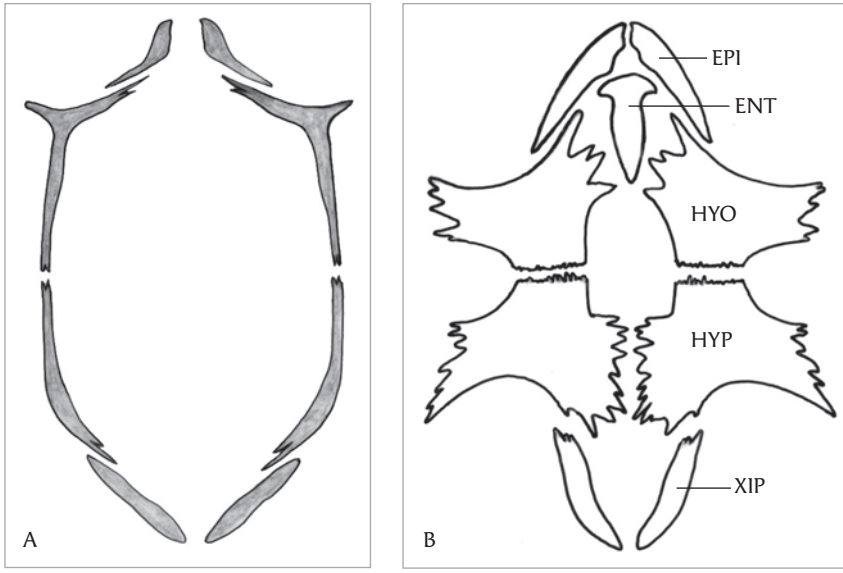


Figure 23. The plastral bones.
EPI epiplastron
ENT entoplastron
HYO hyoplastron
HYP hypoplastron
XIP xiphiplastron

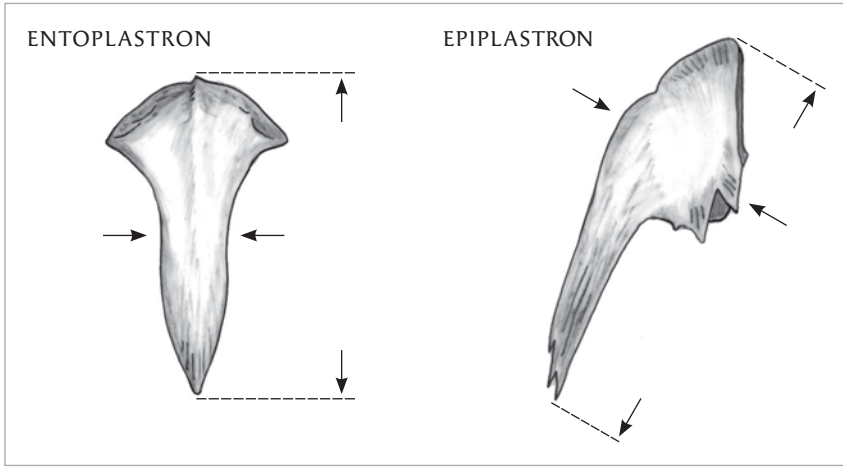


Figure 24. Comparing the dimensions of the entoplastron and the epiplastron.

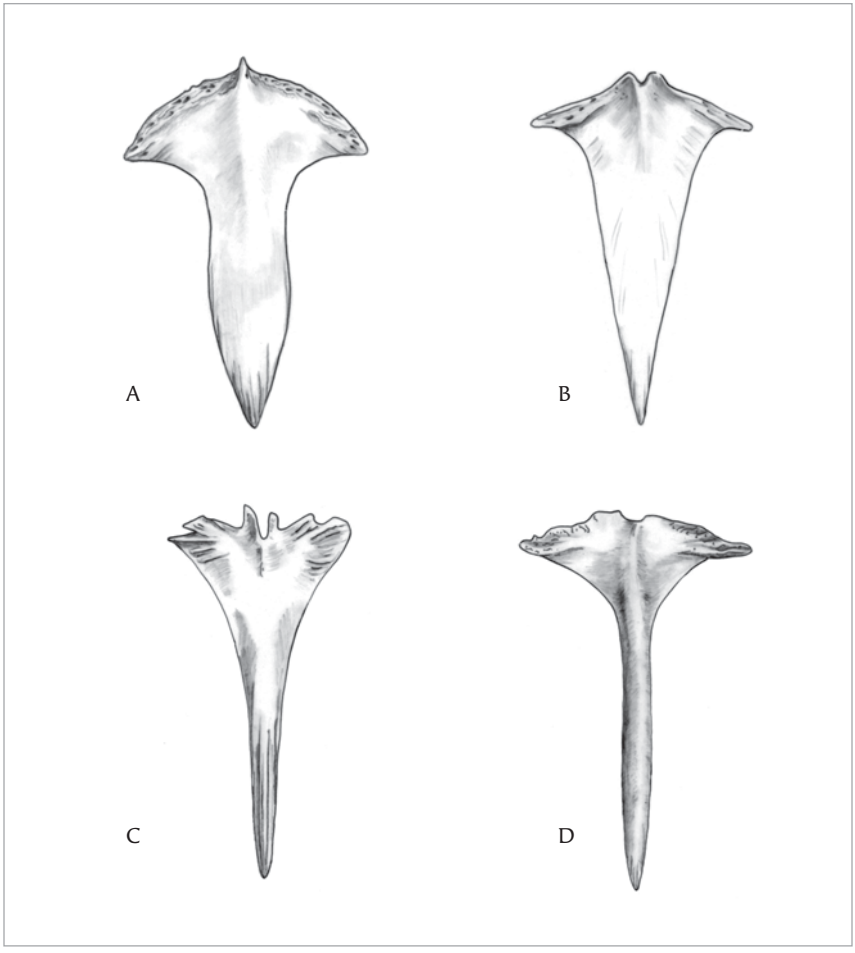


Figure 25. Entoplastrons.

C Shaft of entoplastron tapers to tip in posterior half (Fig. 25A); bone robust . . . . . *Caretta caretta,* loggerhead, p. 53

C Shaft of entoplastron tapers to tip gradually from shoulder (Fig. 25B); bone delicate . . . . . *Lepidochelys kempii,* Kemp's ridley, p. 69

D Anterior end of entoplastron gradually tapers to shaft (Fig. 25C) . . . . . *Chelonia mydas,* green turtle, p. 85

D Anterior end of entoplastron abruptly tapers to narrow shaft Fig. 25D) . . . . . *Eretmochelys imbricata,* hawksbill, p. 97

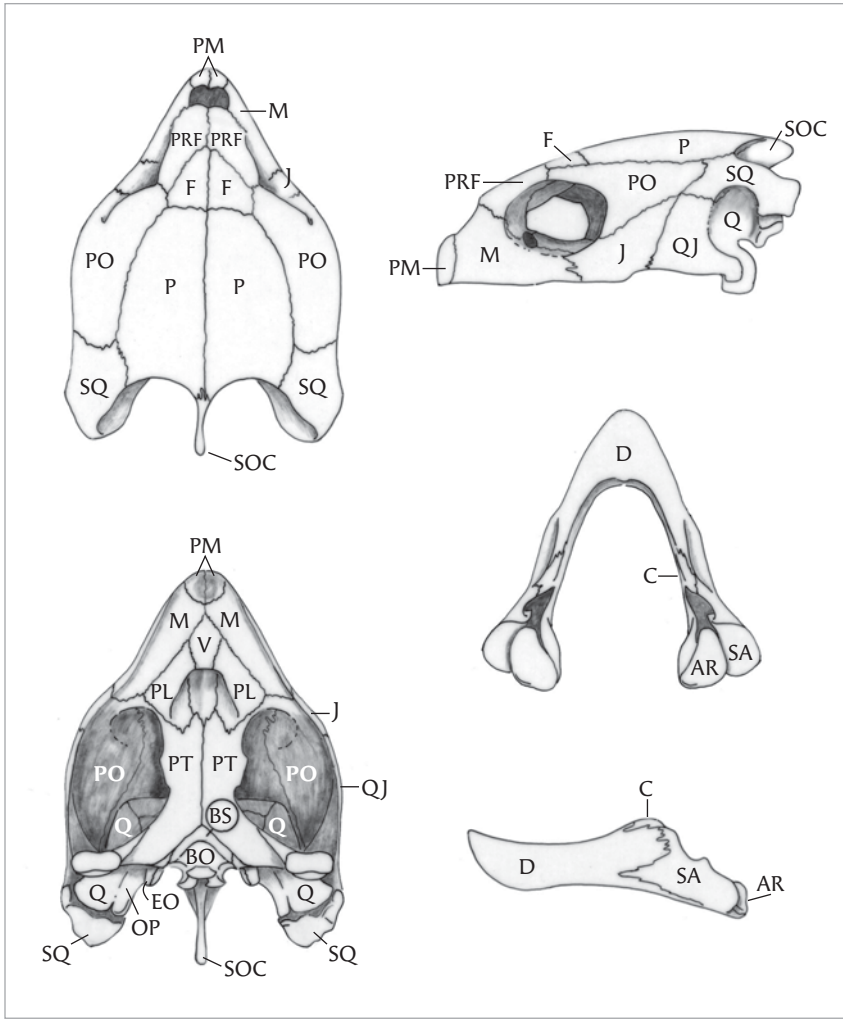


Figure 26. Bones of the turtle skull.

AR	articular	M	maxilla	PT	pterygoid
BO	basioccipital	OP	opisthotic	Q	quadrate
BS	basisphenoid	P	parietal	QJ	quadratojugal
C	coronoid	PL	palatine	SA	surangular
D	dentary	PM	premaxilla	SOC	supraoccipital
EO	exoccipital	PO	postorbital	SQ	squamosal
F	frontal	PR	proötic	V	vomer
J	jugal	PRF	prefrontal		

From A. S. Romer, *Osteology of the Reptiles* (Chicago: University of Chicago Press, 1946).

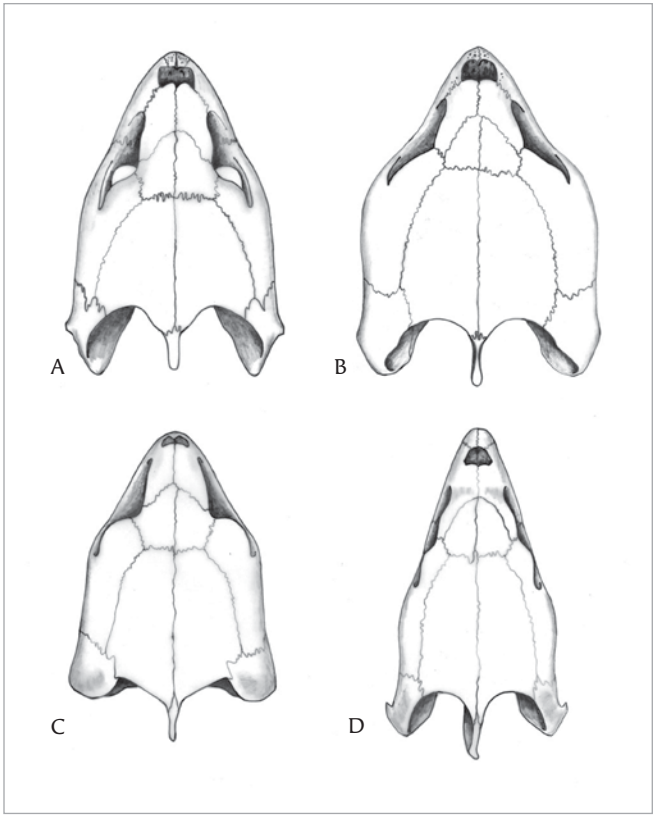


Figure 27. Skulls of four species of cheloniid turtles:
(A) ridley
(B) loggerhead
(C) green
(D) hawksbill

Key to Skull Only

A Upper jaw (and tomium) deeply notched; only the nub of the supraoccipital visible beyond rear of cranial case when viewed from above or below (Fig. 28A) . . . . . .*Dermochelys coriacea,* leatherback, p. 35

A Upper jaw not notched; supraoccipital extends well beyond rear of cranial case (Fig. 28B) . . . . . B

B Anterior suture between premaxillae nearly vertical all the way to base of nasal aperture (Fig. 29A); palatal aspect of basisphenoid flat with the posterior edge forming a shelf (Fig. 29B) . . . . . *Chelonia mydas,* green turtle, p. 85

B Anterior suture between premaxillae slopes back (posterior) to base of nasal aperture (Fig. 29C); palatal aspect of basisphenoid ridged with the posterior edge not forming a shelf (Fig. 29D) C

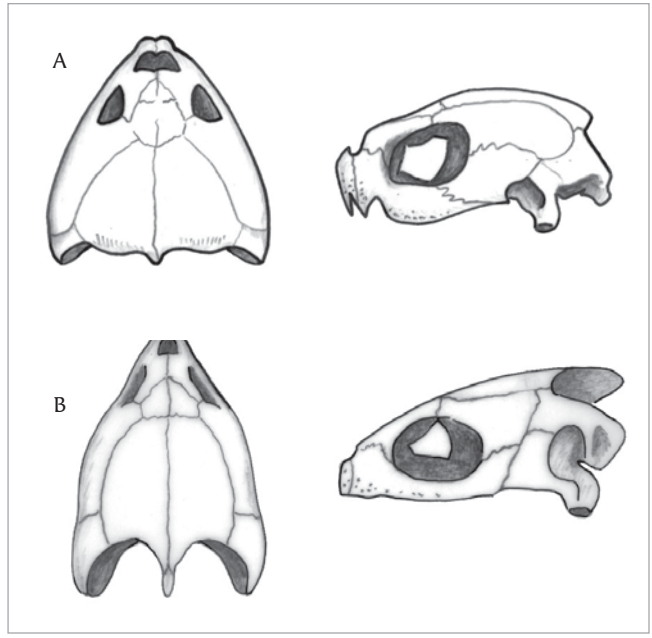


Figure 28.
Upper jaws.

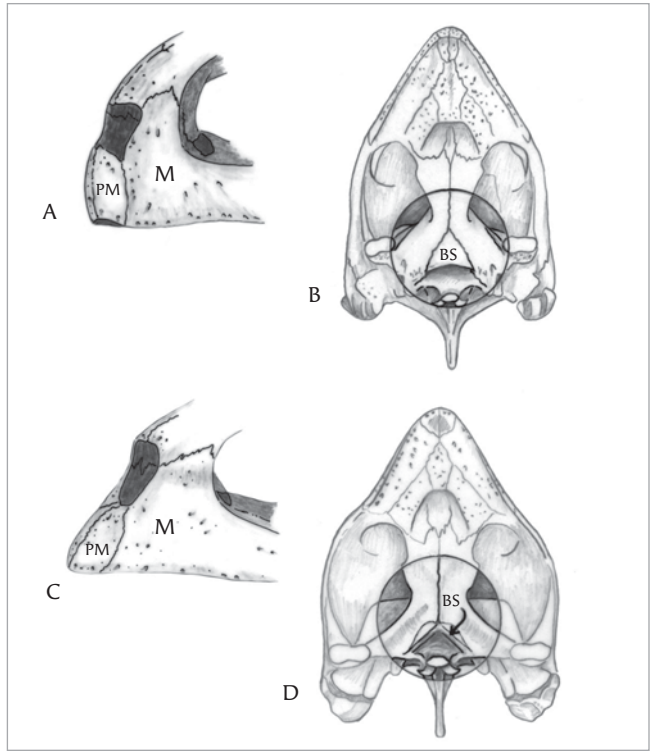


Figure 29. Skulls showing anterior sutures and basisphenoids.

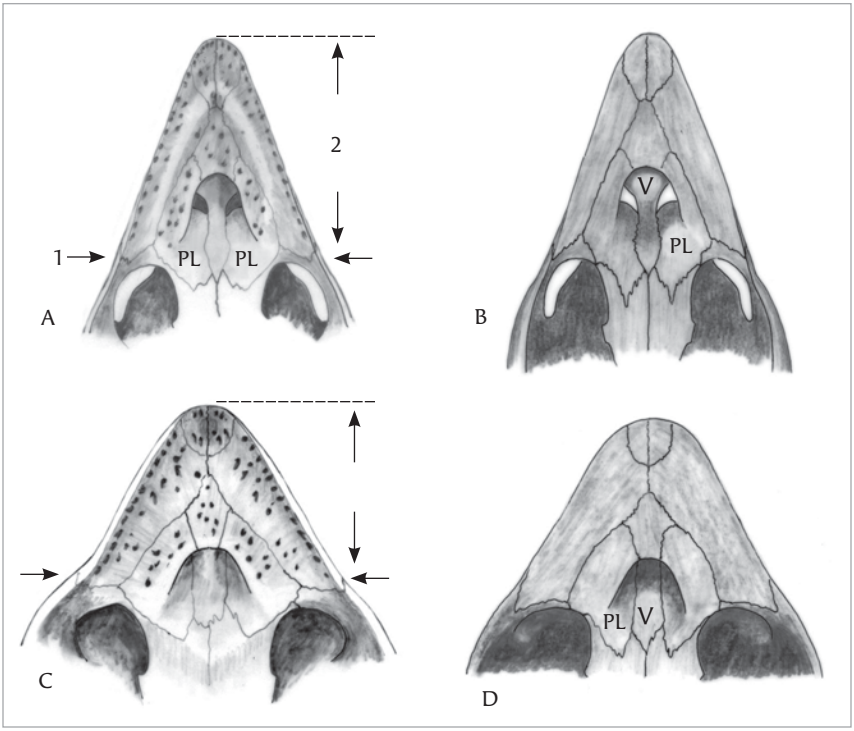


Figure 30. Palatal aspects.

C Distance between posterior tips of maxillae (palatal aspect) less than or equal to the straight-line distance from the posterior tip of the maxilla (1) to the tip of the snout (2) (Fig. 30A); ventral surfaces of vomer free of palatines on roof of choanae or internal nares (palatal aspect) (Fig. 30B) . . . . . *Eretmochelys imbricata,* hawksbill, p. 97

C Distance between posterior tips of maxillae greater than the distance from the tips to the snout (Fig. 30C); ventral surface of vomer at roof of choanae bordered by palatines (Fig. 30D) . . . . . D

D Area of maxilla-palatine suture ridged, with suture at apex of ridge (palatal aspect) (Fig. 31A); vomer touches premaxillae in palatal aspect; postorbital-jugal suture nearly horizontal; frontal touches orbit (Fig. 32A) . . . . . *Lepidochelys kempii,* Kemp's ridley, p. 69

D Area of maxilla-palatine suture flat (palatal aspect) (Fig. 31B); vomer usually does not touch premaxillae in palatal aspect; postorbital-jugal suture slopes downward; frontal usually does not touch orbit (Fig. 32B) . . . . . *Caretta caretta,* loggerhead, p. 53

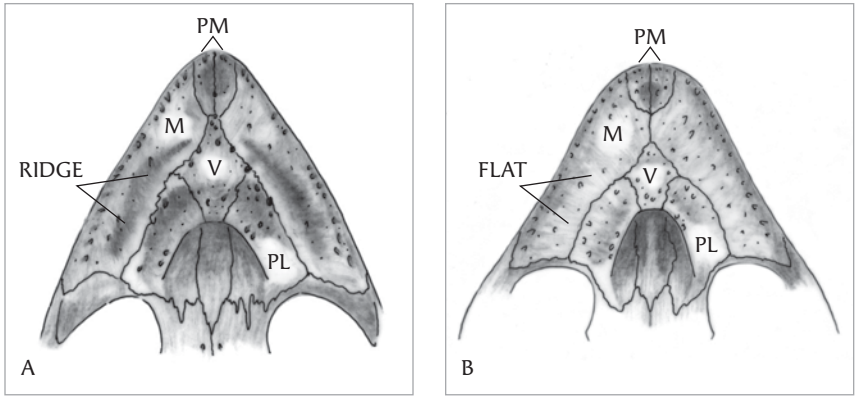


Figure 31. Area of maxilla-palatine suture.

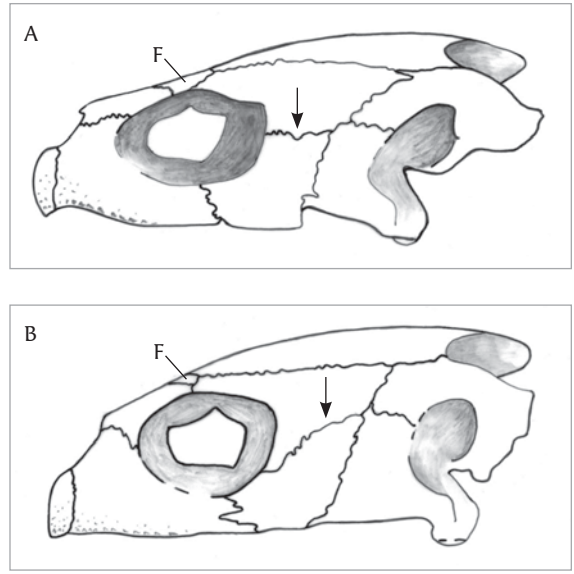


Figure 32. Side view of skull showing postorbital-jugal suture and position of frontal in relation to orbit.

Glossary

adult	Having reached sexual maturity.
amphipods	Animals of the order Amphipoda, class Crustacea. Most are laterally compressed and resemble shrimp.
anaerobic	Without oxygen.
anemones	Solitary, soft-bodied marine animals in the class Anthozoa, phylum Cnidaria. They have unbranched tentacles that some can retract. Most appear sessile (immobile; attached to the substrate) but are capable of movement.
anterior	Toward the head.
axillary	Referring to the armpit; the underside of the limbs at the junction with the body.
bridge	The connection between the carapace and plastron.
bryozoans	Colonial animals in the phylum Bryozoa. Individual animals are minute, and colonies come in many colors and forms: some leafy, some bushy, and some encrusting.
bycatch	Animals or items caught incidentally with the target species in a fishing operation.
carapace	A shield; the bony covering of the back (top) of a turtle. Carapace length is the standard size measurement.
caruncle	An excrescence, a growth.
cervical	Related to the neck of a body or organ.
cestodes	Tapeworms belonging to the phylum Platyhelminthes, class Cestoidea. All cestodes are parasitic.

Cheloniidae	A family within the order Chelonia, class Reptilia, which includes hard-shelled sea turtles.
cloaca	The chamber into which the intestinal, urinal, and genital tracts empty and through which wastes are excreted, copulation takes place, and eggs are laid.
clutch	A group of eggs laid at a single nesting.
commensal	An organism living in close association with another but not parasitic upon it.
convergence zone	A place where different ocean currents meet or converge.
costal scutes	The scutes covering the ribs of turtles belonging to the family Cheloniidae.
cuspate	With sharp points.
crawl	The tracks left by a nesting female sea turtle as she moves across the sand.
crustaceans	Animals in the class Crustacea, phylum Arthropoda, which includes crabs and shrimp.
denticulate	Toothlike, or with toothlike projections.
Dermochelyidae	A family within the order Chelonia, class Reptilia, with a single species: the leatherback turtle.
dimorphism	Having two forms. Males and females of sexually dimorphic species have different external physical characteristics.
distal	In anatomy, the position located farthest from the origin or point of attachment; antonym: proximal.
dorsum	The back or top of a turtle.
Endangered species	A species in immediate danger of extinction, as recognized nationally by the U.S. Endangered Species Act, and internationally by the International Union for the Conservation of Nature and Natural Resources (IUCN).
epibiota	The fauna and flora living on the outside of a turtle.

estuarine	Of or pertaining to an estuary, an area along the coast where fresh water meets saltwater.
gill net	A fish net designed to catch fish by the gills as they try to swim through it. Mesh size depends on the size of the target fish. Gill nets may be stationary or free drifting. Off the southeast U.S. coast, the main target species are king mackerel, pompano, and sharks.
gyre	A discrete revolving body or unit of water. The Great North Atlantic Gyre, for instance, which encompasses the entire North Atlantic Ocean, is a clockwise movement: north up the U.S. Atlantic coast, east across to the British Isles, southward to Africa, and west to the Caribbean.
hatchling	A turtle that has recently emerged from its eggshell.
hydrozoans	Animals of the class Hydrozoa, phylum Cnidaria. Most are polyps that resemble seaweeds or small jellyfish, but some are highly modified with both types of structure.
incubation	The development of an embryo within an eggshell, aided by heat; the period after the time an egg is laid to the time of hatching.
inframandibular	Beneath the mandible or lower jaw.
inframarginal	Beneath the margin of the shell; e.g., inframarginal scales, inframarginal pores.
juvenile	The life stage between hatchling and adult.
keel	A prominent ridge on the surface of a structure.
keratinous	Composed of keratin, the hard organic substance found in horn and fingernails.
long-line	A free-floating main line with many baited lines attached to it. Target species include sharks, tunas, and swordfish.
mollusks	A phylum (Mollusca) of soft-bodied invertebrates usually having a hard shell; the group includes gastropods (snails) and bivalves (clams).

necropsy	An internal examination of a dead animal.
nematodes	Roundworms of the phylum Nematoda. There are free-living and parasitic forms.
operculum	The structure on the foot of certain snails that allows the snail to tightly seal its shell.
opportunistic	Taking advantage of available resources, as opposed to being narrowly selective.
osteoderm	A bone embedded in the skin.
papilla	A small projection or bump.
pelagic	Inhabiting the open sea.
phototaxis	Response to light.
plastron	The bony bottom shell of a turtle.
polychaete worms	Animals of the class Polychaeta, phylum Annelida. Most are segmented and have bristles or setae.
population	A distinct group of organisms inhabiting a specific area.
pore	A tiny opening.
posterior	Behind; toward the rear.
pound net	A stationary net used to trap fishes.
rhamphotheca	The horny covering (sheath) of a turtle's beak.
salp	One of a class of marine animals (Thaliacea) in the phylum Chordata that drift or swim in the open ocean.
sargassum	A brown seaweed in the phylum Phaeophyta, also called "gulfweed."
sclerotic ossicles	A ring of thin bones surrounding the cornea of the eye.
scute	A keratin scale covering the carapace of hard-shelled turtles. For specific names see Fig. 11.
sessile	Stationary, not mobile.

slough	A depression in the ground, usually with sluggish or nonflowing water.
strand	To be left aground by the ebbing tide. Stranded animals are usually dead or dying.
subpopulation	A smaller group within a population.
suture	A joint between two bones that allows very restricted movement.
TED	Turtle excluder device: a panel sewn into a trawl net that shunts out large objects.
Threatened species	A category denoting conservation status. "Threatened" species are not as imperiled as "Endangered" species. See *Endangered species*.
tomium	The cutting edge of the beak.
trematode	A fluke. Trematodes are worms belonging to the phylum Platyhelminthes, class Trematoda, that parasitize all classes of vertebrates.
umbilicus	The abdominal point of attachment of the cord connecting the embryo with its yolk. The umbilical scar is evident in hatchling turtles but is obliterated with age.
ventral	Referring to the bottom; the lower or abdominal surface.
ventrum	The bottom; the lower or abdominal surface.

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Additional Selected Reading

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National Technical Information Service: www.NTIS.gov

Archie Carr Center for Sea Turtle Research online sea turtle bibliography: accstr.ufl.edu/biblio.html

Caribbean Conservation Corporation and Sea Turtle Survival League: www.cccturtle.org

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Index

adult, 8 – 11
  and light, reaction to, 26
  See also maturity
age, 1
albumin, shelled, 15, 48 – 49, 65
alligator, 28, 66
ants, 24, 26
Archelon, 5
armadillos, 25
arribadas, 74, 76

barnacles, 21 – 23
  See also epibiota
bears, 23
behavior
  basking, 45, 55, 89
  emergence, 17 – 18
  feeding, 19
  fire, reaction to, 26
  light, reaction to, 26
  mating, 11
  See also gait; migration; nesting
  See also under green turtle; hawksbill; Kemp's ridley; leatherback; loggerhead
birds, 25
bones
  plastron, 117 – 19
  skull, 120 – 24
bycatch, 30 – 31, 62, 74

carapace, 1, 9, 115 – 16
  See also shell *under species entries*
Caretta caretta. *See* loggerhead
Chelonia mydas. *See* green turtle
Cheloniidae, 4 – 5, 7, 9
conservation, 26 – 29, 107 – 8
  boat collisions and, 31
  commercial fishing and, 28
  dredging and, 31
  of green turtle, 95 – 96
  of hawksbill, 106
  of Kemp's ridley, 76 – 77
  of leatherback, 50 – 51
  of loggerhead, 66 – 67
  vehicles and, 28
crab, ghost, 23

Dermochelyidae, 4
Dermochelys coriacea. *See* leatherback
diet, 18 – 19
  of green turtle, 7, 8, 18, 89 – 90
  of hawksbill, 19, 100, 102
  of Kemp's ridley, 74
  of leatherback, 7, 18 – 19, 46, 48
  of loggerhead, 61 – 62
disease, 11, 21
  green turtle and, 95
  hawksbill and, 106
  Kemp's ridley and, 76
  leatherback and, 50
  loggerhead and, 66
distribution, 1
  of green turtle, 85
  of hawksbill, 97
  of Kemp's ridley, 11
  of leatherback, 35 – 36
  of loggerhead, 53 – 55

egg chamber, 13, 15
egg tooth, 17
eggs, 12 – 18
  of green turtle, 93
  of hawksbill, 15, 104
  incubation of, 16 – 17
  of Kemp's ridley, 75

eggs (*continued*)
of leatherback, 13 – 15, 48 – 49
of loggerhead, 22, 60, 66
predators and, 23 – 26, 67
temperature and, 16 – 17
yolkless (shelled albumin), 13 – 15, 48 – 49, 65
epibiota, 21 – 23
green turtle and, 87, 89, 95
hawksbill and, 100
Kemp's ridley and, 71, 76
leatherback and, 50
loggerhead and, 22, 60, 66
evolutionary history, 4 – 5

fibropapillomatosis, 21, 50, 95
fire, reaction to, 26
fossils, 5

gait, 12
of green turtle, 93
of hawksbill, 104
of leatherback, 48
of loggerhead, 65
ghost crab, 23
green turtle (*Chelonia mydas*), 1, 4, 85 – 96
adaptations of, 89
appearance of: claws, 89; color, 86; flipper, 89; scales and scutes, 87; shell, 87; size, 86; skull, 87 – 88, 121 – 22
behavior of: basking, 89; gait, 93; migration, 86; nesting, 91, 93
conservation of, 95 – 96
diet of, 7, 8, 18, 89 – 90
disease of, 95
distribution of, 85
epibiota and, 87, 89, 95
key to, 111, 112, 114, 116, 119, 121
life history of: eggs, 93; hatchlings, 85, 93; juveniles, 85, 86; maturity, 91
mortality of, 96
parasites and, 95
sex ratio of, 91
status of, 85
growth, 1, 9

hatching, 17
hatchlings, 5, 17 – 18
and fire, reaction to, 26
of green turtle, 85, 93
of hawksbill, 97 – 98
of Kemp's ridley, 70, 71, 76
of leatherback, 40, 41, 43, 46
and light, reaction to, 26
of loggerhead, 54, 55, 56, 58, 61, 65
predators and, 18, 23 – 26
vehicles and, 28
hawksbill, 1, 97 – 106
adaptations of, 100
appearance of: claws, 100; color, 98; flipper, 100; scales and scutes, 100, 106; shell, 100; size, 97; skull, 102, 121, 123
behavior of: diet and feeding, 19, 100, 102; gait, 104; migration, 97; nesting, 104
conservation of, 106
disease of, 106
distribution of, 97
epibiota and, 100
key to, 111, 112, 114, 116, 119, 123
life history of: eggs and incubation, 15, 104, 106; hatchlings, 97 – 98; juveniles, 98; maturity, 102
mortality of, 106
parasites and, 106
predators of, 106
sex ratio of, 104
status of, 97
humans, as predators, 25 – 26

identification
head and all limbs missing, 115
head missing, 112
head only, 113 – 14
intact animal, 110
plastral bones only, 116
skull only, 121

juveniles, 5 – 8
of green turtle, 85, 86
of hawksbill, 98

of Kemp's ridley, 5, 70
of leatherback, 36, 38
of loggerhead, 5, 54, 56

Kemp's ridley (*Lepidochelys kempii*), 1, 69 – 77
appearance of: claws, 73; color, 71; flippers, 73; scales, 73; shell, 71, 73; size, 71; skull, 73, 121, 123 – 24
behavior of: diet and feeding, 74; migration, 70; nesting, 12, 15, 74 – 75
conservation of, 76 – 77
disease of, 76
distribution of, 11, 69
epibiota and, 71, 76
key to, 112, 113, 114, 116, 119, 123
life history of: eggs, 75; hatchlings, 70, 71, 76; juveniles, 5, 70; maturity, 71, 74
mortality of, 76 – 77
parasites and, 76
predators of, 74, 76
sex ratio of, 76
status of, 69

leatherback (*Dermochelys coriacea*), 1, 35 – 51
adaptations of, 45
appearance of: claws, 45; color, 40; flippers, 45; scales, 41, 43; shell, 40, 41; size, 38 – 40; skull, 43, 121
behavior of, 38; basking, 45; diet and feeding, 7, 18 – 19, 46, 48; diving, 45; gait, 48; migration, 11, 36; nesting, 36, 48 – 50
conservation of, 50 – 51
disease of, 50
distribution of, 35 – 36
epibiota and, 41, 50
fibropapillomatosis of, 50
key to, 110, 112, 114, 115, 116, 121
life history of: eggs and incubation, 13, 15, 48 – 49, 50; hatchlings, 40, 41, 43, 46; juveniles, 36, 38; maturity, 48
mortality of, 50
parasites and, 50
physiology of, 36; alimentary canal, 46; body temperature, 45; respiration, 45 – 46
plastic and, 46, 48, 51
predators of, 50
sex ratio of, 50
status of, 35
water temperature and, 36, 39, 45
leeches, 21, 66, 95
Lepidochelys kempii. *See* Kemp's ridley
Lepidochelys olivacea. *See* olive ridley
light, reaction to, 26, 65, 67
loggerhead (*Caretta caretta*), 1, 53 – 67
adaptations of, 61
appearance of: claws, 60; color, 56; flippers, 59 – 60; scales and scutes, 56 – 59, 60; shell, 57 – 58; size, 55, 63; skull, 59, 123 – 124
behavior of, 55; copulation, 63; diet and feeding, 61 – 62; gait, 65; light, reaction to, 65, 67; migration, 54; nesting, 55, 63 – 65
conservation of, 66 – 67
disease of, 66
distribution of, 53 – 55
epibiota and, 22, 60, 66
key to, 112, 113, 115, 116, 119, 123
life history of: eggs and incubation, 63 – 65; hatchlings, 54, 55, 56, 58, 61, 65; juveniles, 5, 54, 56; maturity, 63
mortality of, 66, 67
parasites and, 21, 66
sex ratio of, 63, 64
status of, 53

maturity, 1
of green turtle, 91
of hawksbill, 102
of Kemp's ridley, 71 – 74
of leatherback, 48
of loggerhead, 63
migration, 1, 9, 11
of green turtle, 86
of hawksbill, 97
of Kemp's ridley, 70

migration (*continued*)
of leatherback, 11, 36
of loggerhead, 54
mortality, 28 – 30
of green turtle, 96
of hawksbill, 106
of Kemp's ridley, 76 – 77
of leatherback, 50
of loggerhead, 66, 67

National Marine Fisheries Service, 28 – 29, 50
navigation, 9, 11
nesting, 12 – 13, 15
of green turtle, 91, 93
guidelines for observing, 32
of hawksbill, 104
of Kemp's ridley, 12, 15, 74 – 75
of leatherback, 48 – 50
of loggerhead, 55, 63 – 65
site fidelity and, 15, 50, 65
vehicles and, 28

olive ridley (*Lepidochelys olivacea*), 1 – 2, 75, 79 – 84
appearance of: color, 83; scales, 83; shell, 83; size, 79
key to, 112, 113, 116
status of, 79
ossicles, sclerotic, 48

parasites, 11, 21 – 23
green turtle and, 95
hawksbill and, 106
Kemp's ridley and, 76
leatherback and, 50
loggerhead and, 21, 66
physiology, 29
plants, as predators, 18
plastic. *See under* pollution
plastron, 1, 117 – 19
Platyhelminthes, 21
pollution, 31
light, 26
plastic, 19, 21, 46, 48, 51
predators, 18, 23 – 26, 28
of hawksbill, 106
of Kemp's ridley, 76
of leatherback, 50
of loggerhead, 23, 66
See also conservation

raccoons, 23
reproduction, 8, 11

Sargasso Sea, 5, 54
scales, 58 – 59, 111, 115
See also under appearance *in species entries*
sclerotic ossicles, 48
scutes, 22
See also under appearance *in species entries*
sex determination, 16 – 17
sex ratio
of green turtle, 91
of hawksbill, 104
of Kemp's ridley, 76
of leatherback, 50
of loggerhead, 63 – 64
size, 1, 7
age and, 1
measurement of, 9
See also under appearance *in species entries*
sleep, 8
status, 1. *See also under species entries*
strandings, 29 – 30

trawl nets, 28, 76
turtle excluder device (TED), 28 – 30, 67

U.S. Fish and Wildlife Service, 28